ENVIRONMENTAL RESEARCH

RESEARCH AND TECHNOLOGY BRANCH

ENVIRONMENT-ECONOMY LINKAGES AND SUSTAINABLE DEVELOPMENT IN ONTARIO

RAC Project No. 509C

Ontario
Environment
Environnement

ISBN 0-7778-3042-6

ENVIRONMENT-ECONOMY LINKAGES AND SUSTAINABLE DEVELOPMENT IN ONTARIO

RAC Project No. 509C

Report prepared by:

Hickling Corporation
170 Bloor Street West #704
Toronto, Ontario
M5S 1T9

SEPTEMBER 1994

Cette publication technique n'est disponible qu'en anglais.
Copyright: Queen's Printer for Ontario, 1994

This publication may be reproduced for non-commercial purposes with appropriate attribution.

PIBS 3290E

Acknowledgement and Disclaimer

This report was prepared for the Ontario Ministry of Environment and Energy as part of a Ministry funded project. The views and opinions expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of Environment and Energy, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

The Ministry encourages the distribution of information and strongly supports technology transfer and diffusion. Any person who wishes to republish part or all of this report should apply for permission to do so from the Research and Technology Section, Fiscal Planning and Information Management Branch, Ontario Ministry of Environment and Energy, 135 St. Clair Avenue West, 11th Floor, Toronto, Ontario, M4V 1P5, Canada.

Contents

Figures ix

Tables xi

Preface xiii

Executive summary xv

1. Introduction 1
    - 1.1 Rationale 1
    - 1.2 Historical perspective 3
    - 1.3 Interpretation of sustainable development 5
    - 1.4 New directions in environmental policy 7
    - 1.5 Constraints - the key to sustainable development 8
        - *A comprehensive set of constraints* 10
        - *Constraints at the boundaries* 12
        - *Constraints as indicators* 13
    - 1.6 Summary 14

2. Model concept 16
    - 2.1 Fundamentals of input/output models 16
    - 2.2 Current status of regional input/output models 17
    - 2.3 Basic components 18

3. The environment-economy linkages model 23
    - 3.1 Introduction 23
    - 3.2 Demand 24

3.3 Demand composition effects 26
3.4 Change in technology effects 27
3.5 Spatial resolution 28
3.6 The structure of the LINK model 28
3.7 Summary 30

4. The environmental database 33
4.1 Overview 33
4.2 Design and implementation 33
Structure of the database 34
The GIS system 34
General status of the environmental database 34
4.3 Resource use 35
Mining 36
Forestry 37
Agriculture 37
Fisheries 39
Water Use 39
4.4 Waste generation 40
Air emissions 40
Water borne discharges 41
Solid waste generation 41
4.5 Resources at risk 42
4.6 Conclusion - updating the environmental database 42

5. The economic database 43
5.1 Standard economic inputs 43
5.2 New technical coefficients 48
5.3 Production technologies 49
5.4 Abatement technologies 51
Air pollution abatement technologies 51
Water pollution abatement technologies 52
5.5 Environmental protection industry database 53
5.6 Spatial disaggregation 55

6. Environment—economy linkages under alternative scenarios 56
6.1 Description of the scenarios 56
Base case 56
Scenario 1 — base case Ontario economy in 1990 57
Scenario 2 — export led growth 57
Scenario 3 - substitution of plastic for steel 57
Scenario 4 - contaminant reduction in the pulp and paper industry 57
Scenario 5 - contaminants reduction in metal mining 57
6.2 Results 60

7. Model analysis 67
7.1 Strengths 67
7.2 Limitations 69
7.3 Recommendations for future refinements 70

7.4 Potential applications 71

8. Conclusions 73

References 75

Appendices

Appendix A: Link model users manual
Appendix B: Detailed description of environmental database
Appendix C: Suggested treatment of natural resource accounts in the LINK model
Appendix D: Sewage treatment plant (STP) regression model
Appendix E: Detailed scenario output
Appendix F: Mathematical derivations of LINK model

Figures

Figure I Conceptual framework of the environment-economy linkages model xvii
Figure 1 Classical representation of an economy 20
Figure 2 Conceptual framework of the environment-economy linkages model 21
Figure 3 Basic determinants of economic production levels 25
Figure 4 De-inking process 50

Tables

Table I Environment-economy indicators: deviations from the base case xxiii
Table 1 Environment—economy linkages 22
Table 2 Environmental database categories 34
Table 3 Mapping industrial product price indices 45
Table 4 Mapping raw material price indices 46
Table 5 Consumer Price Index by city, major categories 46
Table 6 Consumer Price Index for Canada, major categories 47
Table 7 Particulate abatement and gas and vapour abatement air pollution abatement technologies 52
Table 8 Estimates of costs and percent reductions by sector based on the maximum technically achievable level of abatement 59
Table 9 Environment-economy indicators under alternative scenarios 60
Table 10 Environment-economy indicators: deviations from the base case 63

Preface

> To enhance understanding of the linkages between the environment and the economy, the Task Force recommends that government, industry, academic and other non-governmental organizations develop new tools and improve existing tools which achieve more efficient and effective environment-economy integration (*Report of the National Task Force on Environment and Economy* 1987).
>
> The lack of any one tool to evaluate the sustainability of development is a major weakness. Although considerable potential may exist to modify or integrate existing tools, new analytical techniques are required (*The Economics of Sustainability*, The Department of Finance 1989).

This study was funded by the Research Advisory Committee of the Ontario Ministry of Environment and Energy[1] in response to an unsolicited proposal submitted jointly by Hickling Corporation[2] and Econometrics Research Limited (ERL). The four principal researchers in the project were:

David Butterfield	ERL
Edward Hanna[3]	VHB

---

[1] The Ministries of Environment and Energy were merged in 1993.

[2] Formerly, VHB Research and Consulting Inc.

[3] Current Position: Principal, JE Hanna Associates Inc.

Atif Kubursi	ERL
Peter Victor[4]	VHB

In addition, a number of people assisted in background research, data acquisition and synthesis and computer programming including Kevin Davis, Brian Singh and Rob Smith of VHB Research and Consulting Inc. and Usman Valiante of HICKLING. As well, Steven J. Spencer, Hirair Hakimian and Moufida Holubeshen of Econometric Research Limited assisted in the environment-economy modelling. Finally, the authors would like to thank Chris Cincar of the Economic Services Branch of the Ministry of Environment and Energy for compilations of potential abatement cost and pollution reduction estimates that were used in scenario analyses.

This report documents the results of this research project. The views presented in this report are solely those of the authors and do not reflect the position of the Ontario Ministry of the Environment and Energy.

---

[4] Current Position: Assistant Deputy Minister, Ontario Ministry of the Environment and Energy.

Executive summary

This study is concerned with the development and testing of models which link and integrate economic activities with environmental systems. Impetus for this work derives from questions about the economy, the environment and sustainable development that are being asked by government, industry and the public and which require new tools of analysis if answers are to be provided.

The study and the model developed for it offers an approach to the quantitative study of sustainable development. It is a synthesis of already established procedures in the fields of modelling economy-environment linkages and environmental impacts and regionally disaggregated economic modelling. The quantitative model of economy-environment linkages in Ontario developed during the course of this project is designed for use in policy research and is focused on resource use and pollutant discharges that are associated with economic activities.

Two distinct, but closely interrelated, components are required to achieve the study objectives. The first involved developing a sound theoretical basis on which a model could be founded. The second component involved constructing a prototype of the model.

Theoretical basis

The approach taken to the meaning of sustainable development in this study starts from the pre-analytic vision of the economy as a sub-system of the ecosphere. The economy consists of the activities commonly referred to as production, distribution and consumption undertaken by humans. Not only is the economy a sub-system of the ecosphere; it is also a sub-system of the larger set of activities that make up social life.

It is within this dependent relationship (ie. of the economy operating within the environment) that this project examines the concept of sustainable development; the requirement that current practices should not diminish the possibility of maintaining or improving living standards in the future.

It follows that, if development is not sustainable because certain limits are not being recognized or respected, then sustainable development requires that economies operate within such limits. The market system can continue to function but it must be obliged to do so by operating within limits imposed by government to avoid the uncertain consequences that nature will ultimately impose.

From a modelling perspective, the concept of limits (ie. to achieve sustainability) can be introduced through a set of constraints expressed mathematically. More problematic is: i) the selection of the variables that should be constrained to capture the meaning of sustainable development; ii) the measurement of such variables; and iii) the process to establish appropriate constraint values. The challenge is to specify a set of constraints that are comprehensive and measurable without becoming too detailed.

The conceptual approach adopted in this study starts with six fundamental biophysical constraints: i) water; ii) air; iii) minerals; iv) solar radiation; v) surface area; and vi) genetic material.

The supply of water, air, minerals and genetic material can be expressed in both quantity and quality terms. In addition, various combinations of these factors lead to significant foundations for biological production and economic activity. For example, climate is strongly related to solar radiation and air quality. The total quantity of each of these six constraints is for all practical purposes assumed fixed. The quality of the supply of these constraints is highly variable and subject to human influence. Substitution among these factors is also variable and often extremely complicated.

The environment-economy linkages model

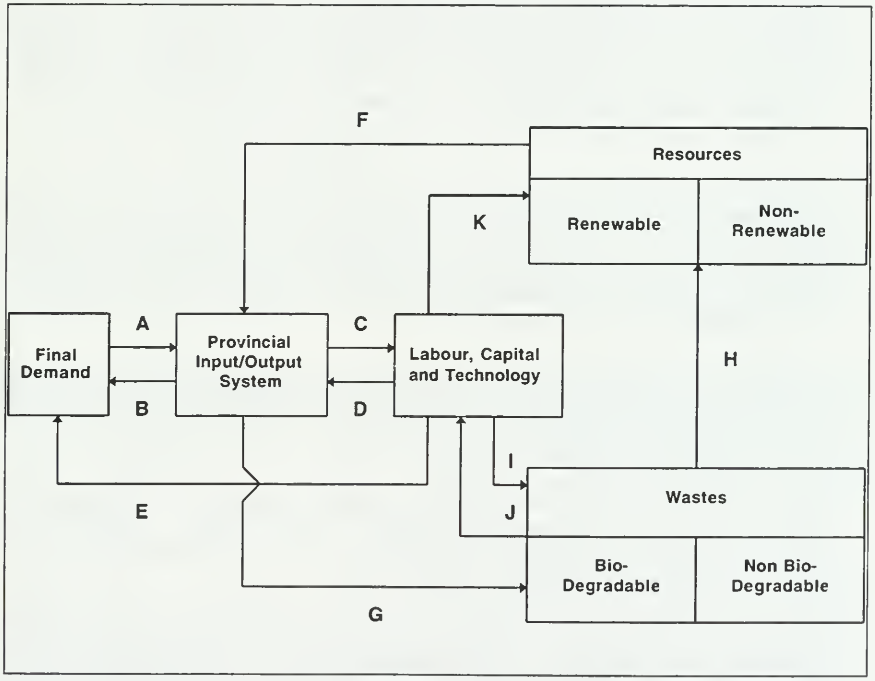
An input/output framework is an accounting system that tracks the flows of goods and services and income and expenditures as they pass through the economy. Elegant mathematical procedures to quantitatively represent these transactions have been developed over the years. In addition, government agencies, like Statistics Canada, have been formed to routinely collect the basic economic data to formulate input/output tables for national and provincial economics. Originally, the applications of input/output analysis were at the national level.

The underlying concept of this project is a recognition that all economic activity requires materials and energy drawn directly and indirectly from the environment and, that ultimately, these materials and energy are returned to the environment as waste products and heat that can cause adverse effects.

Such a "materials/energy balance" perspective of the economy differs markedly from the more conventional view of the economy which focuses on the circular flow of income and the exchange of commodities in markets, and which ignores any linkages between the environment (ie. the economy is a closed circuit model with households supplying the factors of production (land, labour, capital and entrepreneurship) and firms that produce the output and distribute income to households. Application of the approach has been undertaken in various countries but Ontario is unique in having available a detailed, regionally disaggregated economic model for the Province.

Figure I provides a schematic representation of the conceptual framework for the model. The economy, which consists of the provincial input/output macro system, final demand and labour, capital and technology, is shown by the three boxes on the left. The economy uses the environment for inputs to production and as a receptacle for its wastes. In addition, the quality and quantity of the resources available to the economy is affected by wastes placed in the environment. Thus, the environment supports the economy by supplying resources and accepting wastes, two functions which themselves are interrelated.

Figure I Conceptual framework of the environment-economy linkages model



The regionally disaggregated input/output model of Ontario developed in this study already incorporates linkages A, B, C and D and can include exogenous demands for capital equipment (ie. Link E). The present research effort concentrated on the definition and mathematical formulation of linkages E (to make capital expenditures endogenous), F and G so that precise data requirements can be identified and these economy-environment linkages can be incorporated. Linkages H, I, J and K were not included in the application of the theoretical framework. These linkages require disaggregated site specific data currently not available. The exclusion of these linkages resulted in a comparative static modelling system (ie. a system which compares two (or more) equilibrium states of the environment-economy relationship) and does not allow for the explicit optimization of these relationships.

The structure of the LINK model

The LINK model is a conventional input/output framework but is extended to allow for different choices of final demand, technological processes and regional locations. The core of the system is the provincial input/output tables for 1984 as produced by Statistics Canada. The model is "closed" by incorporating consumption and import demand equations that relate these variables to disposable income in the case of consumption and total income in the case of imports.

The final demand categories, which are determined exogenously, are scaled to the base year 1990 using actual Ontario Gross Provincial Aggregates from Statistics Canada, Ontario Economic Accounts. The 1984 commodity composition of investment, government expenditure and exports are used in the model. All prices are adjusted to 1990 values. Growth rates can be stipulated independently by category, expenditures may be scaled upward or downward and then summed to determine the total exogenous final demand that drives the economy.

Since different growth rates can be stipulated to scale the different components of exogenous final demand categories, it is possible to investigate the economic impact of changes in the level or the industrial composition of the economy. Since environmental effects are related to various levels of output and employment by fixed technological coefficients, economic and environmental impacts are determined simultaneously at the provincial level. Regional effects influence the results, albeit in a restricted way.

The LINK model allocates total provincial output to regions in proportion to their historical supply shares. Only the technological changes and the environmental coefficients are region-specific. LINK can be made more responsive to regional economic conditions as demonstrated in several Ontario applications.

The REIM model used by the Ontario Ministry of Natural Resources is the most sophisticated version of a regional input/output model currently in use in Ontario. REIM derives local economic effects with a combination of input/output techniques and location theory. Local consumption patterns also influence the results.

The geographical resolution of the LINK model databases can be defined in terms of watersheds as well as counties. However, to do this requires that all data be geographically referenced for a Geographic Information System (GIS). Environmental and resource use databases compiled for the LINK model have been referenced geographically in order to permit different geographical configurations. However, geographical configuration within a GIS framework could not be done for economic data.

The model results are allocated to counties. Counties are assigned to six Regions which correspond to the regional divisions of the Ontario Ministry of Environment and Energy: Northeastern, Northwestern, Eastern, Central, West Central and Southwestern Ontario and to the Greater Toronto Area.

Economic consequences of macroeconomic trends are identified in terms of total sales (shipments), gross provincial income, taxes by type of tax and the level of government collecting the tax, employment in total and for 25 major industrial groups. Environmental indicators are expressed in terms of air-borne emissions (SO_x, NO_x and VOCs); water consumption; 9 waterborne contaminants; energy by five types of fuels in physical and energy units (crude oil, hydro, natural gas, coal, nuclear, and liquid petroleum) and solid waste by 19 types. The LINK model can be expanded to include the use of mineral resources and forestry products. Both industrial and regional patterns of environmental impacts are presented.

Input/output analysis relies on fixed technological coefficients and constant returns to scale. However, model results are sensitive to changes in technological coefficients, if they are available. For example, the most widely used paper production technologies involves processing wood from forests to make "pulp" which is used to make different types of paper products. An alternative "pulping" technology uses waste paper (called "paper stock" or "secondary fibre") instead of wood. Secondary fibre pulping processes involves a different set of input coefficients than the more widely used wood pulping processes. Secondary fibre pulping, or "recycling", technology coefficients were developed to demonstrate the ability of the system to handle different technological choices.

Technological coefficients that relate industry output to each resource use or pollution release variable are also developed and applied in the model.

The current database provides default values for all of the technological coefficients that relate inputs to outputs and contaminant discharges or resource use to output values in different industries for use in the model. While input-output production coefficients cannot be changed in the current version of the model, coefficients that relate output figures to resource use or pollutant and waste discharges can be changed by the user as new data is acquired.

Furthermore, the coefficients that relate economic output and employment variables can be changed by the user. This flexibility allows users to test the implications of different policy options including achievement of lower pollutant releases per unit of output resulting from the installation of pollution control devices. The Input-Output model shows how these reductions may be counterbalanced in part by increases in emissions resulting from additional expenditures and output by environmental protection industries (EPI).

The LINK model integrates environmental variables within a macroeconomic framework. Many compromises had to be made as data shortages and insufficient evidence on the direction of causation between the environment and the economy precluded operationalizing many potential relationships. Nonetheless, the LINK model is capable of assessing different economic policy or investment scenarios and profiles of the economy and indicate the effects these scenarios could have on pollution discharges, resource use, employment, government finances and a number of other economic variables. Alternatively, environmental protection scenarios will have economic consequences and these can be estimated with the LINK model as well.
The capabilities of the LINK model were demonstrated by postulating five different scenarios and "running" them with the model. The consequences of these scenarios are shown by comparing selected environmental, resource use and economic variables the are computed by the model with the same variables generated under a "base case" or "initial position" scenario.

Models such as LINK require many assumptions and simplifications. The strengths and weaknesses of the model and its many simplifications and compromises are discussed in Chapter 7.

The environmental database

To show the interactions between the economy and the environment, detailed information on the resources used and pollutants generated by each sector of the economy are required. Furthermore, quantitative and qualitative information on the current supply of resources is needed to quantify the constraints with which to define conditions for sustainable development. An major component of the effort involved in this study has been directed at the collection of these data for the Province of Ontario from various municipal, provincial and federal government agencies.

All data were coded into a geographic information system (GIS). However, economic data could not be coded for the GIS. Therefore, only the environmental variables can be aggregated spatially at the present time within the LINK model. As noted, results are presented on the basis of counties and are also aggregated into six MOEE regions.

The environmental data bases developed for this project are as follows:

Resource use

- mining
- forestry
- agriculture
- water use
- energy use

Pollution generation

- air emissions
- industrial water-borne discharges
- hazardous industrial waste
- municipal solid waste
- municipal sewer discharges

At the present time, the LINK model does not incorporate all of the above noted data. The following types of variables are used in the current version of the model:

- air emissions
- energy use
- municipal solid waste
- industrial water-borne discharges.
- water use

Economic databases

The economic data used in the LINK model include the following:

- technical input/output coefficients
- sales, employment and other economic data
- technical coefficients for secondary fibre pulping technologies in the pulp and paper industry
- disaggregated data for the Environmental Protection Industries

The economic core of the input/output model tracks the activities of production, consumption and accumulation within a consistent accounting framework. These input/output accounts are one element of the Canadian System of National Accounts, which is maintained by Statistics Canada.

The technologies that are used to extract materials from the environment, transform them into products, distribute them and dispose of them determine the nature of the linkages between the economy and the environment. Thus, at some point, an analysis of these linkages must address the question of which production technologies are available, which are actually used and what possibilities may exist for changes in production technologies that may increase or reduce the material flows between the economy and the environment.

One of the advantages of input/output analysis is the highly disaggregated representation of economic activity that it offers. The sales and purchases of each commodity by each sector to and from each other sector and to final demand are included in great detail. Underlying these transactions is a technological sub-strata that determines the input requirements for each sector. Economists sometimes interpret the input/output coefficients for each sector as a production function for the sector. However, the technologies themselves are not revealed by these transactions since the transactions result from an aggregation of combinations of technologies employed at each of the establishments comprising a sector.

Many input/output models assume that input/output coefficients do not change over time. This assumption implies that there will be no changes in technology within an establishment or in the relative contribution of establishments using different technologies to the transactions of the sector/industry as a whole. Clearly, these assumptions constitute weaknesses in an analysis of economy-environment linkages over time. Technologies, as expressed by the coefficients, should be variables rather than constants in the model.

There is no inherent restriction in input/output analysis that requires fixed technological coefficients. Historically, they have been employed primarily because of lack of data. Coefficients are estimated using transactions data for a single year. Data for many years, at least at the national level, are available and the coefficients have been shown to be generally stable over time. Such stability is not surprising since the average practice technology of the sector as described by input/output coefficients will be slow to change even when some establishments adopt new technologies, and new firms with new technologies replace existing firms with old technologies.

In this project, the implications for economy-environment linkages of changes in technology were explored in two ways. Alternative production technologies are incorporated in the model for the pulp and paper sector. With increased attention given to recycling, the pulp and paper industry is expanding capacity to use secondary fibre. A typical version of this pulping process has been incorporated in the model as an alternative production technology. The EPI is distinguished as a discrete industrial sector in the model.

Environment-economy linkages under different scenarios

The model developed in this study reveals intricate connections that are not easily discerned without involved analysis. Direct economic impacts estimated by the model give, at best, a partial view of the potential consequences of economic actions. Nevertheless, the quantitative analyses of specific scenarios with the model help to understand the direction and the magnitude of potential consequences. Model results are not predictions or forecasts of effects of scenarios and should not be construed to represent actual cases or likely futures. Scenario analyses include a set of assumptions whose consequences are estimated using the LINK model. The scenarios are designed to provide some initial insights into the dynamics of the relationships between the environment and the economy.

Base Case
The base case or initial position scenario is developed using actual data on final demand categories for 1990 in conjunction with Ontario input/output tables for 1984. All prices used in the model are revised upward from 1984 to 1990 by using industry selling price indices. The exogenous part of final demand (investment in machinery and construction, government expenditures and exports) were assigned their 1990 values to derive the employment, gross provincial income, taxes and environmental impacts presented as the base case. To the extent that the base case replicates reality, any deviation of model results from actual figures were calibrated to the recorded values. Once these deviations were adjusted, the model was able to replicate the actual situation in 1990. Each of the other scenarios are constructed using the calibrated base case version of the model.

Scenario 1 — real historical growth rates
The first scenario accepts the historical growth rates of sectoral output in Ontario between 1981 and 1989 as the basis for projecting output between 1989 and 1990. In other words, this scenario examines the implications of the economy continuing to grow between 1989 and 1990 at the same rates of growth as those observed between 1981 and 1989. Growth rates per sector were imposed on the system in order to generate the observed rates of growth in overall macroeconomic variables in Ontario over the period 1981-1989. The environmental consequences of an economy growing at its historical growth rates were also calculated to correspond to the historical rates of growth in the economy.

Scenario 2 — export led growth
Export led growth is the second scenario. It duplicates the base case with the addition of a 5% growth in exports. All other exogenous variables remain unchanged from their base case values. This scenario is conceived against a background of burgeoning exports as the Canadian dollar exchange value continues to decline against the U.S. dollar. It is also interesting to gauge the impact on the economy and the environment of a lopsided recovery with exports playing the major propulsive force in the economy.

Scenario 3 - substitution of plastic for steel
The Ontario economy continues to experience shifts in the use of inputs prompted by economic and environmental considerations. Plastic is assumed to replace steel to make containers and plastic bottles replace steel and aluminum cans. In this scenario, the economic and environmental effects of an aggressive substitution plan that will see a $1 billion worth of plastic sales displace $1 billion worth of steel sales.

Scenario 4 - contaminant reduction in the pulp and paper industry
Programs to reduce pollutants require capital expenditures and operating expenses in a particular industry. In this scenario, an estimated $1 350 million is to be spent on equipment and other EPI products and services at 26 pulp and paper mills in Ontario in order to achieve a reduction of 8% in ammonia discharges, 42% in total phosphorus and 86% in Total Suspended Solids (TSS) per year. An additional $63 million would be spent yearly on operating the pollution

control equipment. The economic and environmental implications of these expenditures are estimated.

Scenario 5 - contaminants reduction in the metal mining industry
In this scenario a reduction of 31% in TSS, 25% in total cyanide, 72% in copper, four percent in lead and 83% in zinc is possible using a range of technologies at each mine which could cost up to $172 million in capital expenses and about $16 million in yearly operating expenses.

Table I presents the results of these scenarios using the LINK model. The results are presented a in terms of percentage deviations from the base case. These results indicate the types of outputs available from the LINK model. The environmental results presented include water intake and discharges, 3 kinds of air-borne emissions, five different fuels, 19 different types of solid wastes and loadings for 9 separate wastewater contaminants. The model generates a larger set of environmental outputs and differentiates outputs by industry and region (county) which can be accessed by users.

Model strengths

Table I Environment-economy indicators: deviations from the base case

Indicators	Base case	Historical growth rates (% change)	Export led growth (% change)	Substitution ($1B steel to plastic) (% change)	Metal mining contaminant reduction (% change)	Pulp & paper contaminant reduction (% change)
Gross Provincial Income ($billion/a)	277.4	9.0%	2.4%	0.0%	0.1%	0.6%
Employment (million person years/a)	4.59	8.6%	2.8%	0.0%	0.0%	0.7%
Imports ($billion/a)	100.4	8.9%	2.9%	-0.1%	0.1%	0.7%
Taxes ($billion/a)	76.3	11.9%	2.4%	0.0%	0.1%	0.6%
Federal	43.6	13.9%	2.5%	0.0%	0.1%	0.6%
Provincial	22.9	8.9%	2.4%	0.0%	0.1%	0.6%
Local	9.8	9.5%	2.2%	0.0%	0.1%	0.5%
Energy (terajoules/a)	3 519 820	7.9%	3.2%	-0.6%	0.1%	0.6%
Oil	1 818 309	7.2%	3.0%	0.0%	0.0%	0.4%
Coal	536 382	8.3%	3.6%	-3.4%	0.1%	0.8%
Hydro	218 276	8.7%	3.3%	-0.5%	0.1%	0.7%
Nuclear	48 581	8.6%	3.4%	0.6%	0.1%	0.4%
Natural gas	898 272	8.8%	3.4%	-0.4%	0.1%	0.7%
Water (million m^3/a)						
Intake	1 594 640	8.8%	3.0%	-0.1%	0.1%	0.4%
Discharge	1 578 673	8.8%	3.0%	-0.1%	0.1%	0.4%
Emissions (t/a)	763 466	8.5%	3.1%	-0.3%	0.1%	0.5%
SO_x	547 158	8.6%	3.1%	-0.2%	0.1%	0.5%
NO_x	199 959	8.5%	3.2%	-0.4%	0.1%	0.5%
VOC	16 349	8.0%	3.4%	-1.1%	0.2%	1.1%
Waste (t/a)	15 531 508	8.6%	5.6%	2.9%	3.0%	3.4%
Wastewater discharges (t/a)	268 405	8.8%	3.6%	-0.7%	-0.4%	-41.6%

NOTE: Total quantities of each indicator by scenario are presented in Table 8,... of the report.

The model permits users to assess both the economic and environmental implications of different scenarios.

The model structure operates at both the industry and regional levels. The industry level is necessary to capture environmental effects across industries. The regional level of the framework is especially important because environmental impacts are location-specific.

Although not complete, the model incorporates more environmental and resource variables than any other integrated environment-economy model in use in Canada.

Environmental data used in this study were derived from dozens of sources including private sector, provincial and federal agencies and publications. These data sources, contact names and description of available data from these sources are maintained in a separate corporate data dictionary. Update of the environmental database involves contacting the sources identified in the data dictionary periodically and acquiring the latest updates of the environmental data.

Equally important to the discussion of sustainable development is the ability to project the likely economic and environmental impacts of a given configuration of the economy into the future. Since final demand components in 1990 drive the model, it is possible to gauge the sensitivity of the economy to environmental constraints or the environmental impacts of different economic performance levels.

The model has the added advantage of displaying all the environmental coefficients of the system and allowing the user to change each coefficient. This permits testing the sensitivity of the system to different economic or regulatory schemes that aim at changing the pattern of environmental activities.

The implications of changes in technology were explored in two ways. Alternative production technologies are incorporated in the model for the pulp and paper sector. Also, the EPI, which is distinguished as a discrete industrial sector in the model, can supply water and air pollution abatement technologies to the other sectors.

The model provides a flexible, though static, modelling framework to test pollution generation consequences of different economic profiles and for evaluating economic and environmental impacts of alternative economic projections.

A major departure of the LINK model from conventional input/output models is the inclusion of the final demand sectors in the “Make” matrix. In the LINK model, households and institutions—as well as industries—produce waste. In addition recycled material and recyclable waste are distinguished from other commodities. A similar adjustment to conventional I/O models was made to allow the EPI to appear separately and uniquely, illuminating the prominent role given to waste management services and firms in the environmental protection industry.

The model is flexible enough to provide a workable framework that can be extended and modified. For example, if data which quantify the maximum stock of environmental resources available to the economy were incorporated into the model, the analysis could be extended to include the impacts of specific paths of economic activity on the quality and quantity of these stocks. This type of analysis would indicate the sustainability of the chosen level and type of economic activity. The present model provides a general prototype that is amenable to these extensions.

Model limitations

The model is limited in terms of data and structural deficiencies. Economic data were derived primarily from materials published by Statistics Canada. Their reliability is high and these data satisfy accepted accounting identities and procedures. While environmental data are also derived from reliable sources and published materials, they could not be aggregated to correspond exactly to the input/output formats and so there may be a greater margin of error than found in the economic data.

The shortcomings of the environmental data fall into four categories: i) limited suitable data for the 1985 - 1989 period which correspond directly with the economic data; ii) data gaps due to restrictions on dissemination of the information to protect the confidentiality of reporting companies; iii) lack of information on the quality of inputs; and iv) data on stocks proved much harder to obtain than data on flows making it difficult to assess the impacts on resource use of changes in economic activity.

In particular, it was not possible to obtain reliable data on stocks of minerals, wood, water and other resources with which to represent constraints. Consequently, it was not possible to enumerate the cumulative extraction and use of non-renewable resources and their withdrawal from existing natural assets. Such accounting would be necessary to measure reductions in resource stocks such as surface area, genetic material, minerals, fuels, etc.).

As noted, all economic data could not be converted into a GIS format. This shortcoming precluded overlaying counties on watersheds and vice versa. As well, the lack of geographically coded economic data made it impossible to complete the analysis of sewage treatment plant (STP) influent and effluent rates and to incorporate this component of the waste stream into the model.

The problems associated with the use of fixed coefficients over time has already been noted. There are, however, few credible alternatives. Computable general equilibrium models (CGE) do not correspond widely to any particular data set and are plagued with as many, if not more, assumptions as linear, fixed-coefficient models. Whatever advantage price elasticities give the CGE models is generally lost to the fact that only intercepts are made to fit actual data, so that values for the price elasticities have to be taken from other sources. As a result, these models are very sensitive to the values assumed for the elasticities and generate unrealistic forecasting results. Input/output models allow for the direct introduction of structural changes because technologies are specified explicitly. An attempt was made to allow for the use of different production technology coefficients for one sector within the LINK model. However, this component has not been made fully operational in the current version of the model.

It has not been possible to incorporate all of the socio-economic and environmental features that may be deemed vital to a comprehensive environment-economy linkage model. For example, it has not been possible to include population growth and distribution as endogenous variables (ie. variables calculated by the model). This limitation makes it difficult to properly quantify pollution discharges generated by the household (residential) sector which are probably related to population or the number of households rather than the level of consumer spending. Forecasts of changes in the distribution of population by region would allow more accurate regional projections of residential solid and liquid waste generation.

It would also be desirable to incorporate industrial location in the model, so that the regional distribution of industrial pollution could be more accurately forecast. However, the development of models to project changes in the regional distribution of both population and industrial establishments would require a major effort and is probably better approached by a cooperative effort by several ministries.

The structure of the model begins with economic relationships and variables that are translated through the model into resource use and pollution releases. Linkages with causal relationships between environmental quality measures and economic activity are not included in the present model. It would be desirable to incorporate relationships that characterize, for example, how air emissions would affect certain production processes such as agriculture.

Data limitations regarding resource stocks also precluded estimation of shadow prices and sustainable development paths with the model.

Consequently, the LINK model is a consistency model rather than an optimization model (ie. Shadow prices and sustainability pathways can only be derived from a dynamic optimization system. While the LINK model is a comparative static framework, it could be elaborated into a dynamic optimization model but with substantial additional effort.

Not all theoretical facets of sustainable development could be incorporated in the present version of the LINK model although the mathematical structure of the model permits further elaboration of the model to test constraints, linkages and shadow prices. Consequently, the LINK model is a "comparative static" system that compares two equilibrium states of the environment-economy. The model does not allow for explicit optimization of these relationships. Nevertheless, the analysis of theoretical issues in the project exposed key points to be considered and provided the conceptual basis for designing approaches to each of the issues.

Potential applications

In its present form, the model offers a wide range of applications by which economic and environmental trade-offs can be quantified. The model provides a number of quantitative links that tie the economy to certain environmental variables. There are three broad areas where LINK can be useful to policy-makers, environmental scientists and economists:

- to gauge the linkages between economic trends or changes on the environment;
- to quantify trade-offs between different economic activities and paths on the one hand and the environmental impacts that are likely to be associated with the economic change; and
- to measure the sensitivity of the economy and the environment to changes in trends, regulation, incentives, technology and overall economic efficiency.

Recommendations for further work

The limitations described above form the basis for suggested improvements and extensions. Suggestions and recommendations for data refinements and model extensions are noted below.

Data refinements and improvements include:

- improving the reliability and representativeness of the environmental coefficients;
- integrating of the LINK environmental databases with long range transportation of air pollutants and forestry growth and yield models;
- collecting and incorporating stocks of minerals and resources;
- translating county-based economic data into watershed-based data (ie. completely transforming both the economic and environmental databases into a GIS framework); and
- develop and use process based data to describe technology.

Model refinements and improvements include:

- incorporating stock variables into the model such as minerals and forests;
- refine and adopt the extended accounting framework developed within this project (ie. to include environmental impacts on economic variables);
- extend the static model into a dynamic framework (ie. incorporate an optimization routine and choice among processes);
- extend the range of environmental variables incorporated into the model (eg.the incorporation of greenhouse gases and global warming considerations into the model);
- introduce the residential sector into the model and analysis;
- introduce price responsiveness directly into the body of the model; and
- calculation of absolute and relative sustainability indicators.

System refinements and improvements include:

- the addition of more environmental screens and better configuration of all screens;
- greater flexibility in the range of inputs and processing of results, especially the incorporation of technology choice; and
- a GIS based link to the model.

Conclusions

The LINK model provides on approach to integrate the economy and the natural environment. The linkages specified in the model are still rudimentary and unidirectional. The fact that the framework is operational, however, provides a stepping stone from which it is possible to expand and to close a number of open loops. With the extensions and improvements suggested above, LINK could become a basic tool for evaluating economic-environmental consequences.

Substantial effort has been expended to tie the system together and to collect data needed to implement it. Even in its present form, the LINK model can be used to identify the effects of different economic trends on the economy and on certain environmental indicators.

The five scenarios analyzed in this study indicate the utility of the system in identifying the linkages between the environment and the economy over time under different hypotheses about the likely futures of the Ontario economy. While many questions remain unanswered, the questions have been clarified.

1.

Introduction

1.1 Rationale

This research study is concerned with the development and testing of models which link and integrate economic activities with environmental systems. Its impetus derives from questions about the economy, the environment and sustainable development that are being asked by government, industry and the public and which require new tools of analysis if answers are to be provided. Three categories of questions can be identified relating to:

- the economic impacts of resource and environmental policies;
- the resource and environmental impacts of economic policies; and
- the economic and environmental requirements for sustainable development.

Policies designed to protect the environment and conserve natural resources can affect the economy in many ways. Economic activity can be stimulated through an infusion of funds devoted to pollution abatement. At the same time, those industries that must spend large sums on abatement may see their costs rise, possibly to the point at which they become uncompetitive. Similar cost increases may result from restrictions on access to natural resources for conservation purposes. Specific questions arise from these considerations, such as:

- Will economic development in Ontario be constrained by resource conservation and environmental protection?
- How will tax revenues be affected by programs to reduce resource use and contamination of the environment?

- How do resource and environmental policies affect inflation and employment in Ontario?

Economic policies to encourage growth, control inflation and reduce unemployment are normally developed with little consideration of their environmental consequences. However, it has come to be recognised through the work of organisations such as the Brundtland Commission and the National Task Force on Environment and Economy, that economic and environmental policies should be formulated in a mutually supportive manner. Once the integration of economy and environment is acknowledged, many new questions emerge including:

- What are the resource and environmental implications of economic policy initiatives such as the North American Free Trade Agreement and the new tax policies (eg. the Goods and Services Tax)?

- What contribution could a technological shift in transport modes (eg. from private autos in urban areas to public transit, or from gasoline powered vehicles to vehicles powered by electricity or natural gas) make to the achievement of environmental and resource conservation policy goals?

- What will be the impacts on resource use and environmental contamination of major new capital expenditures in Ontario?

- What will be the impacts of industrial subsidies, tax incentives and other economic stimuli on resource consumption and environmental contamination by the economy as a whole, and not just the targeted industries?

Underlying all these questions is a deeper concern with the overall sustainability of the economy at the international, national, provincial and local level. While the debate continues as to the meaning and definition of sustainability, limits on resource use and environmental pollution are likely to be key features of any policies directed at achieving economic and environmental sustainability. Many questions arise out of a concern with sustainable development, such as:

- What would be the economic impacts of substituting renewable for non-renewable resources and biodegradable for non-biodegradable wastes to achieve sustainable development?

- How should the Provincial accounts be modified to incorporate resource and environmental stocks and services?

- Can the future domestic and export demand for forest, agricultural and fisheries products be met from sustainable supplies?

All of the above questions, which are given only as examples, are essentially quantitative in that they call for answers that are best expressed in numerical terms. To date, only limited attempts have been made anywhere to provide the necessary answers (eg. Hoffman et al. 1976), largely because the analytical tools and the data needed to support them, have not been available

Ontario is fortunate in that the availability of relevant data on resources and environment has increased dramatically in the last few years owing to several regulatory initiatives in air pollution (Regulation 308)[1], water pollution (MISA)[2], hazardous wastes (Regulation 309)[3], and municipal wastes. Furthermore, an already substantial database on the province's natural resources continues to be enhanced through Ministry of Natural Resources initiatives such as their Integrated Natural Resources Information System (INRIS).

This study and associated model offers a new approach to the quantitative study of sustainable development. This work is a synthesis of already established procedures in the fields of modelling economy-environment linkages and environmental impacts and regionally disaggregated economic modelling. The resultant quantitative model of economy-environment linkages in Ontario is designed for use in policy research and development focused on sustainability.

1.2 Historical perspective

Interest in the sustainability of economic development can be traced back to the classical economists of the late eighteenth and early nineteenth centuries. The views of such men as Adam Smith, David Ricardo and Thomas Malthus that growth in population would out run growth in economic output led Carlyle to describe economics as the "dismal science."

Although other equally notable economists continued to sound warnings throughout the nineteenth century about the eventual demise of economic growth, the experience of continued growth in the economies of Western Europe and North America diverted the attention of most people, including economists, away from the capacity of the environment to sustain economic growth. The issue returned to the public agenda, though not to that of the economics profession at large, with the publication in the early seventies of *The Limits to Growth* (Meadows et al. 1972).

Using computer simulations and the language of systems theory, the authors of this controversial study showed how various combinations of population growth, natural resource depletion, pollution generation and diminishing food supplies could bring the economy crashing down.

---

[1] Regulation 309 was adopted as part of Ontario's *Clean Air Program*. The objective of the regulation is to regulate air emissions from stationary sources in the province (OMOE 1987).

[2] The Municipal-Industrial Strategy for Abatement (MISA) is intended to achieve "virtual elimination of toxic contaminants in municipal and industrial discharges into waterways" (OMOE 1986). The program encompasses 200 industrial direct dischargers and 400 municipal sewage treatment plants which receive waste waters from almost 12,000 industrial plants subject to the MISA program.

[3] Regulation 309 requires waste generators to evaluate their wastes and, if found to be hazardous or liquid industrial wastes, to register them with the Ontario Ministry of the Environment (OMOE 1985).

Much debate ensued about the methodology, data (or lack of), assumptions and results with economists, ignoring the historical roots of their discipline, leading the charge against limits to growth.

Many valid points were made about weaknesses in the specific formulation of the "world system" adopted by Meadows et al., such as the omission of the price system, the inadequate treatment of innovation and substitution, and the inordinately high level of abstraction in the analysis. After a couple of years of heated debate, most economists withdrew from the field in the belief that, having shown the deficiencies of the Meadows et al analysis, there was nothing more to say on the issue. Others took a different view and soon the negative notion of limits to growth re-emerged in the more positive guise of sustainable development.

According to Pezzey (1989), the term sustainable development first became prominent in the *World Conservation Strategy* (IUCN 1980): "sustainable development is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life"; "sustainable utilization is a simple idea: we should utilize species and ecosystems at levels and in ways that allow them to go on renewing themselves for all practical purposes indefinitely."

The first *State of the World* report by the Worldwatch Institute (Brown et al. 1984) was subtitled "Progress Toward a Sustainable Society" which it defined as "one that shapes its economic and social systems so that natural resources and life-support systems are maintained". With the publication of the "Brundtland Report" (World Commission on Environment and Development 1987) sustainable development passed from a phrase known, for the most part, only to those engaged in or interested in third world development, to a term used by politicians of all levels and stripes in countries around the world.

The definition of sustainable development offered by Brundtland and widely accepted is: "development that meets the needs of present generations without compromising the ability of future generations to meet their own needs." This definition was adopted in Canada by the National Task Force on Environment and Economy (NTFEE 1987) who expanded on it without adding much in the way of real content.[4] Others, such as Daly (1990) and Pearce and Turner (1990) have attempted to refine the definition but an unambiguous and operational definition has yet to emerge. As Pezzey (1989) says, "Most definitions (of sustainability) require that the "quality of life" should not decline over the long-term future. Many can also be interpreted in terms of maintaining an economy's capital stock. However, a relevant definition of capital stock still has to be chosen, and this means judging how significant, essential or substitutable are the various natural and man-made resource inputs to the economy's production processes" (Pezzey 1989).

---

[4] "At the core of the concept of sustainable development is the requirement that current practices should not diminish the possibility of maintaining or improving living standards in the future. This means that our economic systems should be managed to maintain or improve our resource and environmental base so that the generations that follow will be able to live equally well or better. Sustainable economic development does not require the preservation of the current stock of natural resources or any particular mix of human, physical and natural assets. Nor does it place artificial limits on economic growth, provided that such growth is both economically and environmentally sustainable. Sustainable economic development implies that resources and the environment must be managed for the long term, taking into account their possible value in the future as well as their value now" (NTFEE 1987).

The lack of a definition of sustainable development has not prevented policies and programs from being introduced in its name (eg. the Federal Government's *Green Plan* (Government of Canada 1990) and the report of the Ontario Round Table on Economy and the Environment (1992)). Likewise, institutes for sustainable development have been founded such as the International Institute of Sustainable Development in Winnipeg and the Centre for Sustainable Regional Development at the University of Victoria, to name but two prominent Canadian examples.

This flurry of activity in the name of sustainable development supports the view of Daly (1990), Gibson (1991) and others that the lack of an agreed upon definition of sustainable development offers opportunities as well as obstacles. However, in light of the wide range of meanings that have been given to the term, it behooves anyone wishing to use it, to explain what they mean by it. The purpose of the following discussion is to explain the meaning or interpretation of sustainable development underlying this study.

1.3 Interpretation of sustainable development

The approach taken in this research project to the meaning of sustainable development starts from the pre-analytic vision of the economy as a sub-system of the ecosphere. The economy consists of the activities commonly referred to as production, distribution and consumption undertaken by humans. Not only is the economy a sub-system of the ecosphere; it is also a sub-system of the larger set of activities that make up social life.

This economic sub-system is connected to the ecosphere in three main ways:

- the materials and energy required by the economy are obtained from the ecosphere
- the waste materials and energy no longer required by the economy are returned to the ecosphere
- economic activity takes place in the space provided by the ecosphere.

Seen in this light, the economy is an open system through which materials and energy flow from and to the ecosphere. This view of what an economy is may be contrasted with the more conventional way an economy is depicted in most introductory economic textbooks where it is shown as two concentric circular flows with incomes and expenditures going in one direction and goods and services going in the other: a perpetual motion machine with no apparent connection to the ecosphere; an economy with no environment.

It is no coincidence that the birth of modern economics in the late eighteenth century coincided with the start of the industrial revolution. Adam Smith was describing what he saw in his own community as well as what he wanted to see in the whole of Britain: a self-regulating economic system.[5] Moreover, as Polanyi (1944) has explained so well, the transformation of a highly regulated, mercantilist economy to a largely unregulated capitalist economy was accompanied by a separation of the economic functions of society from the rest of social life. To a large extent, the early economists were observing the emergence of the economy as a separate entity. Unfortunately, it is this separateness which has been emphasized in economics. Economists have paid little attention to the insights of other social scientists into the modes and patterns of human behaviour, and they have given even less attention to the links between the economy and the ecosphere.

It can be argued that for most of the past two hundred years, the economies of the world have been small in relation to the ecosphere's capacity to support them. Small here is measured in terms of the material and energy flows associated with economic activity and the geographic space occupied by human settlements and other land uses. Although there are no absolute standards of measurement, exponential growth in economic output within an ecosphere of unchanging proportions has lead more and more observers to concern themselves with the overall *scale* of the economy (Vitousek and Ehrlich 1986; Daly and Cobb 1990). Vitousek and Ehrlich (1986) estimated that of the global net product of photosynthesis, on which all 15 million or so species of fauna depend, 25% is used directly or indirectly by the human species alone (Excluding marine sources of photosynthetic product, they estimate the percentage used by humans is 40%). If these estimates are even roughly correct, the possibilities for the continued expansion of human activities are clearly in question.

Georgescu-Roegen (1976) observed that industrialization has been based on the substitution of non-renewable resources (small stocks, readily controllable flows) for renewable resources (large stocks, minimally controllable flows). Vitousek and Erhlich (1986) show that, in the broadest sense, our ability to increase the supply of renewable resources may be severely constrained in the future. Yet many commentators on sustainable development see the substitution of renewable resources for the diminishing stocks of non-renewable resources as a key requirement. If the opportunities for such substitution become increasingly limited then the only other possibility, if development is to continue in the long term, is to find new ways of substituting manufactured capital for renewable and non-renewable natural assets (ie. resources and environment) (see also, Page 1977).

Doubtless, new technologies will increase the possibilities for such substitution but there are reasons for thinking that these possibilities may be limited. First, finding substitutes for some services provided by nature will be especially difficult. The protection from ultra violet radiation given by the ozone layer is but one example. Access to wilderness is another. The "life support" functions of the ecosphere will be too costly to replicate for all but a very small proportion of the population. Second, in many situations, manufactured capital and natural assets are more appropriately considered as complements to rather than substitutes for natural resource inputs: eg. a pulp mill needs trees, an oil refinery needs oil, and a tractor needs fuel. Increases in the efficiency with which manufactured capital uses resources have been extremely significant during industrialization, but when accompanied by increases in scale total resource requirements can still increase and they have (ie. increased reserves of natural resources) (Barnett and Morse 1963).

---

[5] Smith was born in the Scottish port town of Kircaldy where trade was much in evidence. It is worth noting that his admiration for the free market was tempered by an awareness of the abuses to which it could lead and the need for government intervention to provide a wide range of public services (Viner 1965).

It is within this dependent relationship (ie. of the economy operating within the environment) that this project examines the concept of sustainable development; the requirement that current practices should not diminish the possibility of maintaining or improving living standards in the future.

1.4 New directions in environmental policy

Much of the literature on the economics of environmental policy adopts the framework of cost-benefit analysis. Within this framework, an optimal policy is defined as one in which the marginal benefits are equal to the marginal costs with costs and benefits measured in monetary units so that they can be compared. Ingenious techniques have been developed by economists to estimate an increasingly wide range of environmental benefits and costs and a consensus is gradually emerging as to which techniques most faithfully implement the principles of welfare economics[6] on which cost-benefit analysis is based. However, the role actually played by cost-benefit analysis in Ontario in the formulation of environmental policy, and in setting specific standards for contaminants, remains very limited. Even in other jurisdictions where greater efforts are made to utilize cost-benefit analysis in environmental policy making, its contribution is modest (eg. other jurisdictions in Canada).

There are many reasons why cost-benefit analysis is not used more extensively for environmental policy. These range from various unresolved theoretical problems and the lack of data to a general distrust of using monetary measures for valuing the environment. As a form of applied microeconomics, cost-benefit analysis is most suited to those issues, environmental or otherwise, which are small scale and have only local ramifications. As the problems become larger, in both spatial and temporal dimensions, the *ceteris paribus*[7] assumption of cost-benefit analysis becomes more and more strained.

Uncertainty and irreversibility present special difficulties for environmental policy making. While useful efforts have been made to incorporate these considerations into cost-benefit analysis, there is much doubt as to how successfully this can be done when the problems to be addressed are large scale and wide ranging. Climate change caused by the accumulation of greenhouse gases in the atmosphere is but one example where cost-benefit analysis is too limited a tool. Depletion of the ozone layer by the release of CFCs and the contamination of the Great Lakes with persistent toxics are two more examples of environmental problems that cannot be adequately addressed using conventional cost-benefit analysis techniques.

---

[6] Welfare economics is concerned with the way economic activity could be organized to maximize social economic welfare by changing the goods (or resources) produced, or the distribution of these goods among consumers, to make some people better off without making anyone else worse off.

[7] *Ceteris paribus* means all other things being equal or the same. For example, cost-benefit analysis typically relies on market prices to value marketed goods and services. These market prices reflect the current market equilibrium. If a large-scale project is sufficiently large to affect market prices (i.e., the supply/demand equilibrium in the market), the *ceteris paribus* assumption would be violated and the basis for the cost-benefit analysis flawed.

The limitations of cost-benefit analysis for dealing with large scale environmental problems has not impeded environmental policy making in these areas. While the concept of optimization[8] remains important, it has never contributed much in a formal sense to environmental policy. This not to say that environmental policy is definitely non-optimal. Faced with uncertainty as to the costs of climate change, ozone depletion and intoxication of the Great Lakes, combined with some evidence that the worst case outcome could be very bad indeed, policies built around quantitative limits on the release of the contaminants causing these problems make good sense. What these limits should be remains problematic, but there is a clear indication that environmental policy makers, with considerable public support, are prepared to set limits without full information on the cost and benefits of these policies.

The same is true with respect to the protection of natural resources. Quotas have been established to protect stocks of whales. Outright bans have been imposed on the harvesting of endangered species. Maximum harvest rates for forests have been set. The conversion of agricultural land to urban uses is often restricted. Wetlands are protected from draining and so on. None of these measures have been based on formal economic optimization calculations using benefit and cost functions.

These are all examples of how the impact of economic activity on the environment is being more and more regulated through the adoption of *quantitative limits* on the resources used by economic activity and the wastes generated. Unlike emission standards expressed in concentrations (eg. micrograms per litre) or in terms of production (kilograms per tonne of output), and unlike standards which prescribe certain practices (eg. secondary treatment of waste waters or requirements for land reclamation), the trend in environmental policy making is to set absolute limits on the flows of material between the economy and the environment, especially for those flows believed to be associated with the most severe types of impacts (eg. persistent toxic contaminants). Moreover, as the scale of economic activity increases, more and more of these types of limits can be expected. Whether or not they will be sufficiently stringent, adequately enforced and comprehensive enough to provide the protection required of them is unclear. Nevertheless, they may well be the best immediate means of ensuring that the economic activity of humans maintains some sort of balance with the rest of the ecosphere.

1.5 Constraints - the key to sustainable development

An increasing reliance in environmental policies on absolute limits gives an important clue to the meaning of sustainable development. To a large extent, the concern that development is not sustainable stems from a combination of: i) concern that certain trends projected into the not too distant future cannot be sustained; and ii) a belief that the economic system cannot be relied upon to make the necessary adjustments without some form of government intervention.

---

[8] The concept of optimization is based on selecting a course of action where the marginal benefits equal the marginal costs.

It follows that if development is not sustainable because certain limits are not being recognized or respected, then sustainable development requires that economies operate within such limits. The market system can continue to function but it must be obliged to do so by operating within limits imposed by government to avoid the uncertain consequences that nature will ultimately impose.

From a modelling perspective, the concept of limits as discussed here can be introduced through a set of constraints expressed mathematically. More problematic is: i) the selection of the variables that should be constrained to capture the meaning of sustainable development; ii) the measurement of such variables; and iii) the process to establish appropriate constraint values. The challenge is to specify a set of constraints that are comprehensive and measurable without becoming too detailed. At one extreme is the idea inspired by Georgescu-Roegen (1971) that since economic activity converts low entropy matter-energy (ie. natural resources) into high entropy matter-energy (ie. consumer products), it is the use of low entropy matter-energy that should be constrained as a matter of policy since the market system does not contain the necessary information or provide appropriate incentives to do so.

The difficulty with this approach is that measures of entropy are too general to be useful in policy analysis. Put another way, there is only a rough correspondence between low entropy matter-energy state and value of a resource or product. For example, a process which converts a highly concentrated deposit of lead into lead dispersed in the atmosphere increases entropy and converts a positive source of value into a negative one. However, if the lead is dispersed less widely and is concentrated in highly populated areas, the increase in entropy will not be as great as in the previous case, but the threat to human health will be greater and the net value to society less.

At the other extreme, one can imagine an extremely detailed set of constraints which account for all sorts of variations in local conditions but for which the data are unavailable. Also as the number of constraints increases, the potential for substitution among constraints increases.[9] Furthermore, it is questionable whether sustainability requires a particularly detailed set of constraints for some environmental features. For example, it is the total quantity of greenhouse gases that must be constrained, not the emissions from particular locations or sources. The specific allocation of the constrained total quantity to individual sources is an important policy question but not one which is directly related to sustainability.

---

[9] The potential for substitution is one of the most difficult elements of assessing sustainability. It is unlikely that there is one unique configuration of the economy and the environment that is sustainable. Instead, it is much more likely that there are a great number of sustainable configurations, represented by differing levels of resource consumption and waste production. Each of these sustainable states will be contained by a different set and different levels of constraints, particularly if highly detailed and disaggregate sets of constraints are defined in each case.

The approach adopted in this project to defining a set of sustainability constraints is to start with six fundamental biophysical constraints:

- water;
- air;
- minerals;
- solar radiation;
- surface area; and
- genetic material.

The supply of water, air, minerals and genetic material can be expressed in terms of both quantity and quality. In addition, various combinations of these factors lead to significant foundations for biological production and economic activity. For example, agricultural soil requires certain specific combinations of minerals and surface area in combination with specific climatic conditions. Similarly, climate is strongly related to solar radiation and air quality.

The total quantity of each of these six constraints is for all practical purposes fixed. The quality of the supply is highly variable and subject to human influence. Substitution among the constrained factors is variable and often extremely complicated. For example, the amount and quality of agricultural land (arable surface area) may be a primary indicator of sustainable development. Through technology and energy inputs, losses in supply due to urban expansion may be compensated by improvements in the quality and corresponding yield of the remaining agricultural land. However, such compensation is not unlimited since the available surface area, genetic material and solar radiation, are fixed. Only by maintaining a careful integrated accounting of the primary constraints will limits be revealed.

A comprehensive set of constraints

For the purposes of this project, the definition of the constraints is partly influenced by the availability of data (eg. there is little data regarding genetic material applicable for use in this project). The review of the environmental data base in Chapter 4 describes the variables for which data are currently available and on which constraints can be imposed. In general, to quantify the constraints that, according to the definition used in this study to define sustainable development, data are required with respect to:

- the total current supply in quantity and quality terms of each primary constraint;
- the combinations of primary constraints that lead to the direct connections with the economy (eg. agricultural land produces agricultural goods accounted for in the economic framework);

- the production coefficients for primary renewable and non-renewable resources with various combinations of primary constraints;
- the waste emission (ie. air, emissions, water effluents and material wastes) coefficients from various forms of economic activity which effect the quality and quantity of the biophysical constraints); and
- the relationships between the waste emissions and the productive capacity of the environment.

A major component of current activities is the reconciliation of these *ideal* information requirements with available data. Concurrently, the expression of the constraints and their relationships are being developed in a form consistent with the overall input/output model framework. The biophysical response models[10] are not at this time included in the model framework, however, efforts are being made to ensure that essential connections are possible. For example, the air emission rates of various pollutants are being calculated for various forms of economic activities. The model forecasts future emission levels. Forecasts of ambient air quality, however, require complex air dispersion and transport modelling which is beyond the scope of this project. A primary challenge is to obtain sufficiently disaggregate and comparable data so that the environmental and economic data can be connected. Typically, the environmental data are highly site-specific and lack comprehensive measures of overall system condition. Conversely, the economic data are typically aggregated for the entire province giving good measures of overall system conditions but lacking in detail for evaluating local site-specific environment-economy interactions. This gap between the environmental and economic data sources is a major challenge for analysing sustainability. It is this gap that limited and shaped the final form and the application of the theoretical framework developed in this project.

A related issue involves the role of current market prices and technologies in defining available supplies. Mineral reserves are defined according to the costs of extraction and prevailing markets. An economic reserve of gold is much less concentrated than an economic reserve of iron. Consequently, the supply of gold and iron in terms of quality and quantity is defined to a considerable extent by existing prices. If market prices are skewed due to their failure to account for unsustainable draw-downs of resource stocks or externalities associated with their consumption and ultimate disposal, the **economic** supplies of resource stocks may not be accurately reflected in the environmental database.[11]

---

[10] Biophysical response models capture various relationships including those between the productive capacity of the resource base and management impacts and between emitted wastes and the supply of natural resources to the economy. For example, SO_2 emissions can reduce the productivity of forests reducing the supply of wood fibre to the forest products industry. Biophysical response models can be used to quantify the impacts of varying levels of SO_2 emissions from various sources on wood fibre supplies.

[11] This example highlights the need to express the primary constraints in both quantity and quality terms.

If the environmental costs of mining and disposing of wastes associated with iron are much higher than those associated with gold and these costs are not captured by prevailing market prices, the economic supply of iron will be inflated and an unsustainable level of consumption will be encouraged.

A further complication involves the development of new technology to permit accessing and extraction of previously unavailable or uneconomic reserves. In Ontario (and elsewhere), there are mining operations based on extracting minerals from the waste tailings of earlier mining operations. These tailings recovery operations are feasible due to changing market conditions and technology.

The impact of technology on the constraints occurs also with respect renewable resources and waste discharges. By varying the combination of inputs the level of agricultural output can be changed dramatically. The "Green Revolution" in agriculture came about largely as a result of significantly increasing the energy and material inputs due to changing farming technology. Similarly, rates of emissions of gaseous, liquid and solid emissions from economic activity have steadily decreased over the last three decades or so as a result of technological improvements.

It is not feasible to include in a model, all technological shifts that may occur. A range of technologies can be included where appropriate data are available. These technologies need to be defined in terms of input and output coefficients like all other economic activities in the model. The inclusion of such technologies provides the opportunity for technological change to respond to binding environmental constraints.[12] The question remains as to what forces regulate the development and application of these alternate technologies.

Constraints at the boundaries

The meaning of sustainable development for a region such as Ontario raises some important questions about Ontario's relationship with the rest of the world. If development in Ontario is placing demands on the national, continental and global environment for resources and waste disposal, and if the prospects of meeting these demands over the long term are in question, then such development in Ontario cannot be regarded as sustainable unless technical change and substitution are expected to reduce the dependency. This is not to say that sustainable development requires self-sufficiency, only that some attention needs to be paid to the sustainability of the links between regions if sustainable development is to prevail in any one of them.

The approach taken to this issue in this project is to introduce a set of constraints on the imports of some categories of purchased goods into Ontario and the exports of wastes out of the province (both through the market and external to it). For example, a constraint may be imposed on the import of wood and wood products from the Amazonian rain forest since this diminishing resource is unlikely to be able to sustain the level of production reached in recent years and the market price of the imported wood fails to reflect its full value.[13] Moreover, limits on the exploitation of the rain forest may be introduced by the Brazilian government which would also limit Ontario's access to wood from this area.

---

[12] In the version of the model described in this report, an example of substitute technologies is provided for the pulp and paper sector.

A more significant import which may have to be constrained when considering sustainable development in Ontario is energy from fossil fuels: oil, gas and coal. These sources of energy play an important role in Ontario's economy today but over the longer term, limits on their availability may have serious implications for economic development in Ontario. Again, the imposition of explicit quantitative limits on imported sources of energy for exploring the meaning of sustainable development presumes that the market prices of these resources inadequately reflects the long term limits on their supply and the environmental damage caused by their use.

Consider also the export of wastes. From the point of view of Ontario alone, it is doubtful that emissions of greenhouse gases have any significant consequences for the global environment. Ontario's contribution is just too small to make a difference. However, as part of the larger national and international effort to control greenhouse gases, Ontario may have to limit its emissions of these gases. In other words, the export of greenhouse gases from Ontario may have to be constrained if sustainable development in Ontario and elsewhere is to be achieved. Likewise, the export of hazardous wastes from Ontario is not likely to go unchecked and reliance on others to accept such wastes over the long term is not consistent with sustainable development in this province.

In addition to the physical inflows and outflows between Ontario and the rest of the world which may be restricted, there is a question of what overall balance of trade is required for sustainable development to prevail. Over the long term, it is inconsistent with sustainable development for Ontario to maintain an increasing net trade deficit[14] with the rest of the world. Therefore, another component of the meaning of sustainable development in Ontario is that the value of imports and exports with the rest of the world be equal and a constraint can be imposed to that effect.

Constraints as indicators

One of the most problematic, yet topical, aspects of sustainable development is the identification of indicators that show whether an economy is moving towards or away from sustainability. An early objective of this study was to produce a set of sustainability indicators.

One approach is to start from the assumption that the overall economic goal of development is the maximization of value added net of capital depreciation, ie. the sum of personal and corporate incomes generated in the province minus capital depreciation which is equal to net provincial product (NPP), subject to the constraints required for sustainability. For any constraint that is binding (ie. which reduces NPP from what it would be without the constraint) a 'shadow' price[15] can be estimated. This shadow price shows how a small change in the level of the constraint will increase or decrease NPP. The more binding is the constraint, the higher is its shadow price. These shadow prices, one for each constraint, can be multiplied by the difference between the *actual* level of the constrained variables and the level specified in the constraint. The sum total of this calculation represents a 'sustainability deficit', that indicates the extent to which the economy is operating non-sustainably. This deficit could be deducted from NPP to take account of the degree of non-sustainability of the economy.[16]

---

[13] Global environmental services provided by the Amazonian forest such as climate regulation and genetic diversity not easily capitalized by the forest owners will not be reflected in market prices.

[14] Note the term "trade deficit" should be interpreted broadly and not measured in strict economic terms exclusive of non-marketed and formally traded goods and services such as those provided by the global and regional environment.

One problem with this approach to adjusting the national or provincial accounts is that it assumes that all of the prices of commodities traded in the economy are unaffected by the existence of the constraints. An alternative is to use the shadow prices of the constraints to estimate a new set of general equilibrium prices for each commodity. These new prices will include not only the value of all purchased inputs required in the manufacture of each commodity, but also the extent to which the provision of each commodity draws directly and indirectly upon the constrained variables that define sustainability. These adjusted prices can then be applied to the quantities of goods and services traded to estimate an adjusted NPP.

1.6 Summary

The preceding discussion provides an overall content within which the environment-economy linkages model described and assessed in the remainder of this report was developed. This study involved two distinct but closely interrelated components. The first involved developing a sound theoretical basis on which a model could be founded. The second component involved constructing a prototype of the model. The preceding discussion sets out the theoretical issues faced and the analysis of these issues in the context of practical environmental and economic policy analysis.

---

[15] The calculation of shadow prices assumes that a formal optimization routine, like linear programming, is included as part of the model. Shadow prices for each constraint are a normal part of the output from such routines.

[16] There is a great deal of interest in ways of revising the system of national accounts to more adequately address environmental and resource issues (ERL and VHB 1990; and Ahmad, Serafy and Lutz 1989). Various proposals have been made and the debate of which should be adopted is a lively one. Some of the proposals would change the definition and measurement of GNP, others would change the definition and measurement of NPP. Still others would leave the standard definitions and measurements intact but would create a set of satellite accounts to record the extent and value of changes to the resource base and quality of the environment. One approach that incorporates the depletion of natural resources in the system of national accounts with minimal change to the standard accounting conventions has been developed in this project (see, Appendix C for a further description).

Not all of the theoretical facets of sustainable development could be incorporated in the prototype model. Importantly, however, the analysis of theoretical issues exposed key points to be considered and provided the basis for conceptually designing approaches to the issues even if all of the varied aspects of the ultimate analytical tool could not be incorporated in the initial prototype version. These theoretical issues are presented in Appendix F.

The mathematical structure of the model described in Appendix F captures the intention of the points raised above (ie. constraints, linkages, shadow prices). However, in the development of the model the degree of its complexity increased, making it difficult to implement these considerations. As such, LINK is a "comparative static" system that compares two equilibrium states of the environment-economy. The model does not allow for explicit optimization of these relationships and, as such, it does not solve directly, for example, shadow prices. However, the LINK model provides a number of operational links between the economy and environmental indicators through a set of equations (or relationships) that can eventually be transformed into a set of constraints within the broad framework developed in Appendix F and discussed above.

2.

Model concept

2.1 Fundamentals of input/output models

Input/output analysis was developed by Wassily Leontief for which he received the Nobel Memorial Prize in Economics. In its most basic form, an input/output framework is an accounting system that tracks the flows of goods and services and income and expenditures as they pass through the economy. Elegant mathematical procedures to quantitatively represent these transactions have been developed over the years. In addition, government agencies, like Statistics Canada, have been formed to routinely collect the basic economic data to formulate input/output tables for national and provincial economics. Originally, the applications of input/output analysis were at the national level.

Early regional studies which used input/output models (Isard and Kuenne 1953) relied on a national table of technical coefficients in conjunction with an adjustment procedure that was designed to capture some of the characteristics of the regional economies, since specific tables for particular regions did not exist. More recently, interest in economic analysis at the regional level—whether for individual provinces (states) or for a group of provinces, a county, or a metropolitan area—has led to a series of modifications of the basic model to reflect the particular characteristics of small economies.

There are three basic features of a regional economy that influence the characteristics of a regional input/output model.

1) Although data at the national level are obviously some kind of an average of data from individual producers who are located in specific regions, the structure of production in a particular region may be identical to or it may differ significantly from that recorded in the national or provincial input/output table. For example, the technology for producing electricity at Niagara Falls is totally different from that used at Pickering,

paper production technologies vary enormously by region, and so on. For these reasons, the early methodology for regional input/output applications which used a "modified" national table has given way to coefficient tables that are actually constructed for a particular region on the basis of data specific to that region. In the event that a regionally specific input/output table is not feasible, production process data that reflect the specific technological structures of regions are used to modify the input/output table coefficients.

2) It is generally true that the smaller the economic area, the more dependent that area's economy is on trade with other regions. Interactions over space become critical and a method is needed to govern the nature and volume of these interactions. For example, the location of demand and supply outside of the area may greatly affect prices of goods and services. Location theory has been used to generate gradients that defined regional economic contours.

   Furthermore, the more open the economy, the greater are the leakages and the smaller are the impacts that are retained at the local level. It follows that a good deal of effort is needed to characterize the economic base of the local economy and its capacity to retain economic benefits and its share in provincial and national activity. It also demands that a comprehensive provincial framework is in place to ensure the underlying equality relationships (ie. balancing of flows) are respected at the local level.

3) Regional economies interact not only through the exchange of goods and services, but also through labour and financial flows. The levels and intensity of these interactions influence the ability of a particular location to partake in the economic processes of the larger economies of which the smaller economies are parts. Furthermore, the spending patterns of households and other final demand sectors may differ over regions for a variety of reasons which include climatic considerations, income distribution patterns and social phenomena.

There is an enormous body of work on input/output modelling at the regional level (eg. Isard and Kuenne 1953 and Hirsch 1959). A basic bibliography of regional works was compiled Giarratani, et al (1976). A very thorough discussion of the details involved in regional input/output analysis and development is provided by Isard and Langford (1971). Overviews of regional input/output models are to be found in Polenske (1980) and in Miernyk (1982).

2.2 Current status of regional input/output models

Leontief published one of the first papers on extensions to input/output analysis to include the environment (Leontief 1970). The integration of the principle of materials balance and input/output analysis to capture all economic-environmental linkages was proposed by Victor (1972) and implemented by him using preliminary data for Canada. This work has recently been described by Pearce and Turner (1990) as "the best and most detailed exposition" of integrating environment into economic analysis using input/output analysis. They also add that "it should be evident that advances in this area could be very fruitful". More recent studies have been undertaken by other economists though most of these have lacked a suitably rich and detailed database on resource and waste flows.

Two other initiatives of similar intent, which were more ambitious than this proposal and only met with partial success, are the Strategic Environmental Assessment System (SEAS) model developed and used by the U.S. Environmental Protection Agency, and the Socio-Economic Resources Framework developed by Statistics Canada (Hoffman et al. 1976). Work is being undertaken by Statistics Canada to integrate resource accounts in their national input/output model but the agency is not working on regional (ie. sub-provincial) versions of this input/output model.

2.3 Basic components

The underlying concept of this project is a recognition that all economic activity requires materials and energy drawn directly and indirectly from the environment and, that ultimately, these materials and energy are returned to the environment as waste products that can cause pollution.

Such a "materials/energy balance" perspective of the economy differs markedly from the more conventional view of the economy which focuses on the circular flow of income and the exchange of commodities in markets, and ignores linkages to the environment (Figure 1) (ie. the economy is a closed circuit model with households supplying the factors of production (land, labour, capital and entrepreneurship) to firms that produce the output and distribute income to households). The materials/energy balance perspective on the economy was first suggested by several economists twenty years ago (eg. Victor 1972). Application of the approach has been undertaken in various countries but Ontario is unique in having available a detailed, regionally disaggregated economic model for the Province.[17]

Figure 2 provides a schematic representation of the conceptual framework for the model. The economy, which consists of the provincial input/output macro system, final demand and labour, capital and technology, is shown by the three boxes on the left. The economy uses the environment for inputs to production and as a receptacle for its wastes. In addition, the quality and quantity of the resources available to the economy is affected by wastes placed in the environment. This portion of the system corresponds closely to the economic system shown in Figure 1. Thus, the environment supports the economy by supplying resources and accepting wastes, two functions which themselves are interrelated. Table 1 reviews these interrelationships.

The regionally disaggregated input/output model of Ontario already includes linkages A, B, C and D and can deal with exogenous demands for capital equipment (ie. Link E). The challenge of this study was to incorporate the other linkages in the analytical framework. The research effort concentrated on the definition and mathematical formulation of linkage E (to make capital expenditures endogenous) F and G so that precise data requirements can be identified and these economy-environment linkages can be incorporated. Linkages H, I, J and K were not included in the application of the theoretical framework. As discussed in section 1.5, these linkages require disaggregated site specific data currently not available. The exclusion of these linkages resulted in a comparative static modelling system (ie. a system which compares two (or more) equilibrium states of the environment-economy relationship) and does not allow for the explicit optimization of these relationships.

---

[17] The regionally disaggregated economic model was developed by Econometrics Research Limited to analyze the relationships between the provincial and regional economies.

Care was taken to provide, to the greatest reasonable extent, the possibility for the inputs and outputs of this model to be linked with existing biophysical models represented by Linkages H and K.

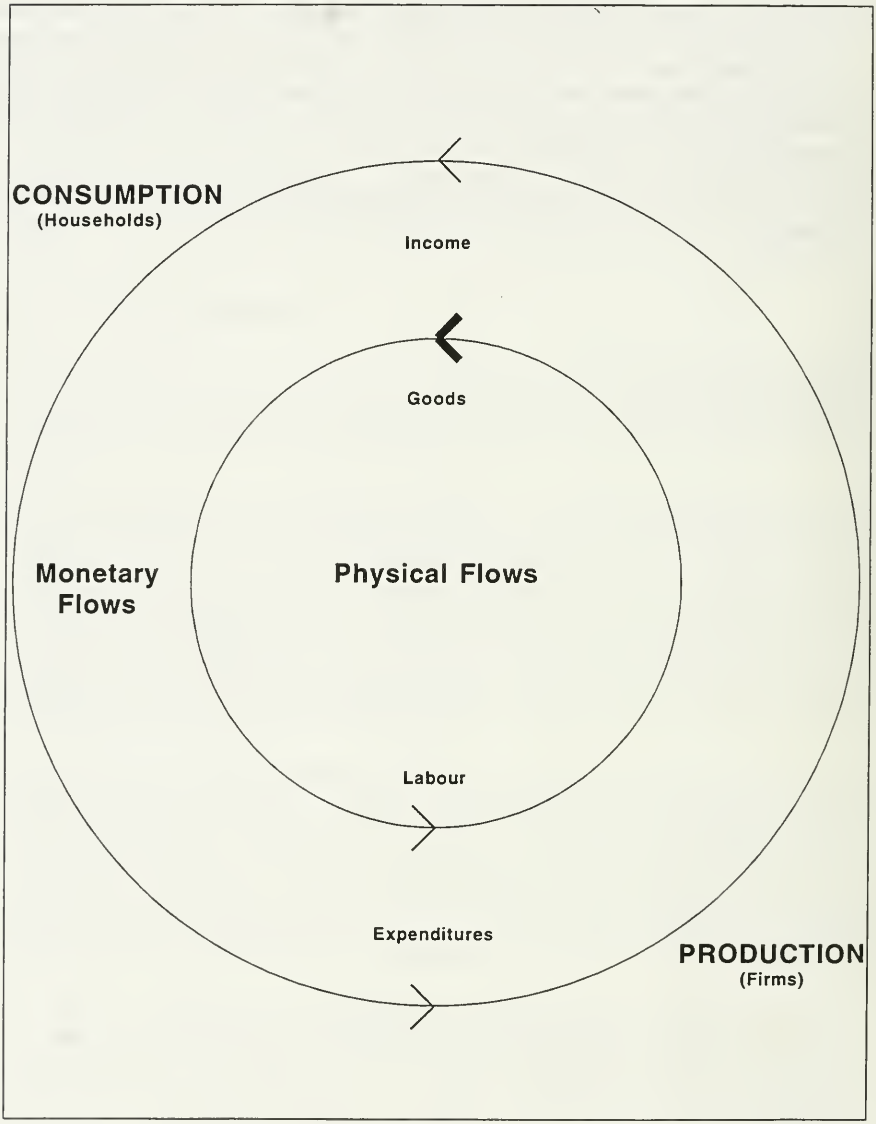


Figure 1 Classical representation of an economy

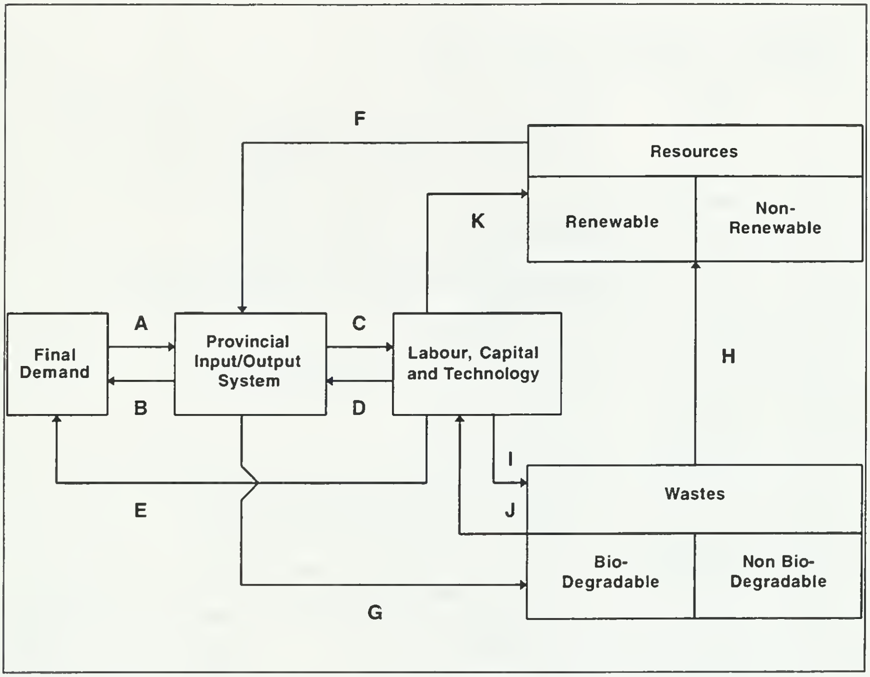


Figure 2 Conceptual framework of the environment-economy linkages model

Table 1 Environment—economy linkages

Linkage A[a]	The demand for products determines what the economy produces. The input/output system identifies where the production will take place and what technologies will be used.
Linkage B[a]	The economy generates income and taxes which, in turn, support the demand for products and services.
Linkage C[a]	As a result of economic activity, additions are made to the capital stock, such as buildings, roads, machinery and information production.
Linkage D[a]	Capital (including labour as "human capital") provides services to the economy that are essential for production.
Linkage E[b]	Requirements for new capital goods add to the demand for products from the economy.
Linkage F[b]	The economy requires resources from the environment which are obtained by industries such as logging and mining, or through direct extraction in the case of water withdrawals.
Linkage G[b]	Economic activity generates wastes which, in this context, include all types of unwanted byproducts coming from industry or individual consumers. The environment provides a service by either degrading or assimilating these wastes.
Linkage H[c]	Wastes disposed into the environment can affect the capacity of the environment to provide some types of resources e.g., the effects of acid deposition on forestry and agriculture. These linkages are represented by biophysical response models.
Linkage I[c]	Changes to the economy's capital stock generate wastes from worn out or obsolete equipment and structures.
Linkage J[c]	The economy's capital stock is vulnerable to the effects of environmental pollution through damages to buildings and equipment and human health effects.
Linkage K[c]	The supply of resource stocks can be enhanced by technological improvements or capital investments.

NOTES: a - Already included in Ontario regional input/output models.
b - Theoretical, mathematical formulation and application of the linkages within the LINK model developed in this project.
c - Theoretical and mathematical formulation developed in this project but not applied in the LINK model due to data limitations.

3.

The environment-economy linkages model

3.1 Introduction

Standard economics textbooks portray the economy as a closed circuit model with households supplying the factors of production (land, labour, capital and entrepreneurship) to firms that produce the output and distribute income to households (see Figure 1). The monetary value of production is equal to the sum of factor payments as profits are treated as a residual item that balances the two accounts—production and income. Since households spend all of their income in this model, total production is equal to total expenditures (consumption) and gross domestic product consists of three equal components; production, expenditures and income.

This simple economy ignores the fundamental relationships that connect the economy to the environment. The links are multidimensional and quite complex as discussed in Chapter 2. Fundamentally, this relationship is one of the environment "supporting" economic activity by supplying resources and accepting wastes. Ultimately, the optimization of this relationship to maintain or improve future living standards is a sustainable approach to human development. It is therefore difficult and meaningless to evaluate economic activity in isolation of its interface with the natural environment. A more complete assessment of economic activity will also include the environmental impacts of this activity on the absorption of natural resources and the production of waste. Similarly, any discussion of the environment in isolation of the economic costs and impacts on the economy will provide only a partial and sometimes naive perspective on environmental issues and concerns.

The preceding chapters described the theory and background to sustainable development and the conceptual basis for the environment-economy linkages model. This chapter provides a more detailed description of the model itself.

The environment-economy linkages model (LINK model) is rooted in the framework of sustainable development discussed in Chapter 1. A set of comprehensive linkages between the economy and the environment and maintaining physical and economic balances between the human economy and natural environment are the ultimate goals of the model.

In its present form LINK is simply a compromise between the more sophisticated conceptualization of the model developed in Chapter 2 and in Appendix F and standard macroeconomic models. Commodity balances and industrial outputs are linked to the environment along two basic lines. Through forward links to the environment as a sink and backward links to the environment as a source of renewable and non-renewable resources. Space is configured in terms of counties and regions and different technologies are featured as different processes to produce the same commodity.

Thus, the LINK model consists of four basic elements of economic and environmental linkages: i) level (or scale) of production and consumption; ii) changes in the composition of demand; iii) changes in technology; and iv) changes in the location of economic activity. The basic organizing principle of the system is that economic forces drive environmental changes.

The line of causation starts with demand forecasts. These demand changes require specific output and employment levels related to existing technology. The technology requires certain levels of resource inputs and produces certain quantities of waste. The model, in its current form, is a static system in the sense that it does not permit feedbacks from the environment to the economy to determine the optimal relationship (ie. links H, I, J and K in Figure 2 are not included in the model).

Three basic determinants of change are shown in Figure 3. These three factors are discussed following.

3.2 Demand

The level of economic activity is driven by final demand. Changes in final demand are not always translated into pure output and income change. If the economy is operating with excess capacity, high levels of unemployment and low inflationary expectations, only then will changes in final demand be reflected primarily in output changes. If, on the other hand, the economy is operating at or near full capacity and full employment, most of the change in final demand will be manifested in higher prices.

The LINK model is a demand-driven, output-adjusting model. The model translates demand changes fully into output changes. To the extent that this is not the case some adjustment is required to partition the output change between prices and quantity changes. Only output changes, however, relate directly the economy to the environment. Output change is the primary connection between economic and environmental impacts.

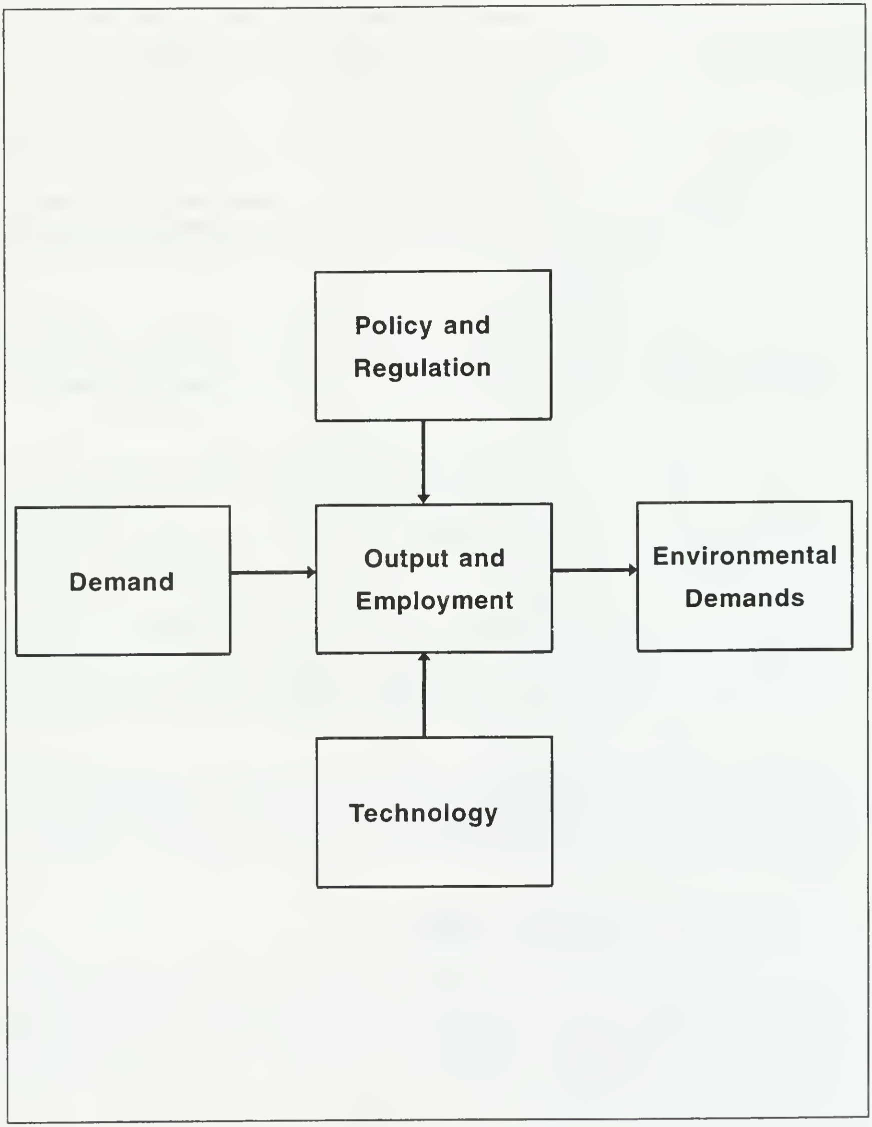


Figure 3 Basic determinants of economic production levels

It is necessary through increased resource consumption and increased waste production to adjust demand changes to 1990 constant dollars. The system deflates these values to the 1984 technical relationships embedded in the input/output system as produced by Statistics Canada.

An increase in demand for any particular product, say steel, will result in an equivalent increase in the output of the steel industry to meet the increased demand. This increase in the output of steel and the income it creates within steel production is referred to as the direct economic impact of the increase in demand. But the increase in steel production calls for an increase in iron ore production and energy as well as other inputs. These intermediate inputs have to be produced also. All intermediate goods needed to produce the intermediate inputs of iron ore and energy must also be accounted for.

It might seem that this chain reaction would go on without end. In fact, the mathematics described in Appendix F show that it is possible to calculate easily and quickly the entire set of linkages. The sum of these connections or intermediate adjustments are referred to as the indirect economic effects or impacts.

The changes in the system do not end here. With each change in production, income is generated and received by labour, owners of capital and land as well as by entrepreneurs. These incomes are typically spent on goods and services. The output change that results from the expenditures of these incomes are referred to as the induced economic effects or impacts of the original change in final demand.

The original change in final demand results in multiple impacts on the economy. The effects are often expressed as a multiplier (ie. the overall magnitude of the combined economic impacts relative to the initial direct impact). The multiplier is reduced by leakages into taxes, saving, liquidity demand, and imports. The major reduction is likely to come from increases in prices.

Input/output analysis typically excludes leakages into liquidity preference and decouples investment from interest changes. The most restrictive assumption is that of no price change in response to demand increases. Some flexibility exists, particularly in terms of demand changes and different mixes of the components of this demand. The impact of changes in the composition of demand is examined next.

3.3 Demand composition effects

The restrictive nature of input/output analysis is mitigated by the added flexibility and the rich menu of results it generates. This flexibility and richness are partly provided by the detailed representation of the economy provided by input/output analysis. The economy is disaggregated into the constituting components—commodities and industries. This is a unique element of the input/output table that Statistics Canada produces on a regular yearly basis for the national economy and at five year intervals for the provincial economies.

Industries can and do produce more than one commodity and commodities are produced by more than one industry. (Appendix F provides a more detailed discussion of the technical aspects of these relationships.) The separation of commodities and industries permits the separation of technological coefficients from market shares. The former are more stable than the latter and are less susceptible to change. Breaking final demand into several commodities permits direct investigation into the impact of changes in tastes or relative prices on the relative commodity compositions of demand. For example, a $1 billion change in consumption can have a totally different economic and environmental impact than a $1 billion change in investment demand. The two demands may involve totally different arrays of commodities and therefore industries and technologies.

Differences in demand composition may also require a different mix of domestic and imported products. This difference may have implications for the location and scale of economic activity and therefore the consequent environmental impacts.

In general, final demand is divided into five major categories—consumption, investment, government expenditures, exports and imports. Each one of these categories may in turn be divided into a number of sub-categories. For instance, investment is divided into construction and machinery. It is the changes in demand in each of these categories that effect the environment-economy relationships developed in the LINK model.

3.4 Change in technology effects

In general, firms choose the combinations of inputs to produce their output in a manner that minimizes their total cost. As such when the prices of inputs change, firms respond by substituting cheaper inputs for the more expensive ones. For example, if the cost of oil were to rise, firms respond by economizing on the use of oil and substituting other cheaper energy sources. The extent to which inputs are substitutable is determined by the level of knowledge, existing technology and institutional constraints. At any given time, there exists a fixed combination of inputs (commodities) for the production of any industry output. This mix of inputs is generally referred to as the technological (or use) coefficients.

Input/output analysis is based on the strong assumption that the average practice technology is used throughout the economy. The average practice technology for a sector is derived by summing for all firms producing a similar output the uses of inputs (physical or monetary) to produce their output. This total is normalized (divided) by the total quantity of output from the sector to calculate technological coefficients.

These coefficients are assumed to remain unchanged when the scale of output changes. This assumption is reasonable for short periods of time (ie. 5 to 10 years at most). However, technology changes and firms typically have several technological options from which to choose. Restricting technological change indefinitely will result in unrealistic results and will exaggerate the durability of existing average practices and the impacts of these practises on the environment.

From a sustainable development perspective, this raises a central question. Namely, to what extent is it reasonable to assume that technological changes (ie. more efficient use of existing resources or substitution among inputs) can be relied on to overcome environmental constraints? Technological change is the product of invention. Invention by its nature is extremely difficult to forecast and model. The best that can be done is to forecast the minimal level of technological adjustment needed to remain within given environmental constraints.

3.5 Spatial resolution

There are significant differences among the various regions of the province in terms of their biophysical environment, labour supply, consumption patterns and industrial bases. The capacity to produce goods varies significantly from region to region. The regional output will match the differing capacities of these regions and will result in different technological and performance indices.

For example, paper can be produced in two different ways. In general, the northern part of the province produces paper using a higher proportion of virgin pulp than southern paper plants. The latter will tend to increase their reliance on recycled paper due to their competitive advantages relative to virgin pulp paper sources dependent on the availability of exploitable forest reserves. Simply, the northern mills rely more heavily on virgin fibre due to the proximity of supply. Differences in product technology also exist. Thermal and chemical processes are used for producing paper from virgin fibre, whereas, de-inking technologies are required for recycled paper. The latter technology uses a different combination of chemicals and energy than the thermal-chemical-mechanical technologies of the north. This effects the form of the environment-economy relationship developed.

By regionally disaggregating the provincial economy, these technological differences can be captured. The average practice technology is defined for the region rather than the province as a whole. Likewise, the environmental inputs and outputs can be forecast regionally according to the prevailing technology. This permits much greater precision in relating economic activity and environmental effects.

3.6 The structure of the LINK model

The LINK model is conceived within the conventional input/output framework but is extended to allow for different choices of final demand, technological processes and regional locations. The core of the system is the provincial input/output tables for 1984 as produced by Statistics Canada. The model is closed by incorporating consumption and import demand equations that relate these variables to disposable income in the case of consumption and total income in the case of imports.

The final demand categories that are exogenously determined are scaled to the base year of 1990 using actual Ontario Gross Provincial Aggregates from Statistics Canada, Ontario Economic Accounts. The commodity composition of investment, government expenditure and exports were left as they were in 1984. All prices in the system were expressed in terms of 1990 prices. Growth rates by category can be stipulated independently. Once these rates are determined, expenditures may be scaled upward or downward and summed to result in the total exogenous final demand that drives the economy.

Since different growth rates can be stipulated to scale the different components of exogenous final demand categories, it is possible to investigate the economic impact of level and compositional changes in the economy. Since environmental impacts are related by fixed technological coefficients to the various levels of output and employment, economic and environmental impacts are determined simultaneously at the provincial level. When regional impacts are determined then regional differences are allowed to influence the results, albeit in a restricted way.

The LINK model is not an inter-regional model. LINK allocates output to the various regions in proportion to their historical supply shares. Only the technological changes and the environmental coefficients are region specific. LINK can be made more responsive to regional economic conditions as demonstrated through a number of similar Ontario applications. The most sophisticated regional application of a comparable regional input/output model is in the REIM model currently used by the Ontario Ministry of Natural Resources. In REIM, local impacts are derived using a combination of input/output techniques and location theory. Local consumption patterns also influence the results.

By changing the geographical resolution of the databases, the model can be adjusted to operate on the basis of watersheds instead of on the basis of counties. To facilitate rapid redefinition of geographical units, use of a GIS framework is essential. This requires that all data are geographically referenced at a suitable level of spatial resolution. The current databases in the model have been geographically referenced to permit rudimentary geographical configurations. The environmental data is fully configured within a GIS framework. The same has not been possible in the case of economic data. Less than 20 percent of all industrial data were assigned GIS coordinates (longitudes and latitudes). Statistics Canada, which produced the conversion routine from postal codes to GIS coordinates did not have a complete set of conversions for of Ontario at the time the economic coefficients were being tied to the model.

The model results are allocated to six basic regions—northeastern, northwestern, eastern, central and southwestern Ontario, and the Greater Toronto Area (GTA)—and within each region to the individual constituent counties. Both the economic and environmental impacts are generated at the county level.

Economic impact of macroeconomic trends are identified in terms of a number of indicators. The list includes: sales (shipment), value added (GPI), taxes by type of tax and the level of government collecting the tax, employment in total and by 25 major industrial groups. Environmental impacts are presented in terms of a number of indicators which include emissions (SO_x, NO_x and VOCs); water consumption and discharge; energy by five types of fuels in physical and energy units (crude oil, hydro, natural gas, coal, nuclear, and liquid petroleum), industrial waterborne contaminant loadings and 19 types of solid wastes. A description of the economic and environment indicators included in the LINK model are provided in a glossary at the end of this chapter. Shadow prices for these environmental factors and depletion of the stock of resources were not included in the model due to a lack of data. The system has been designed for future expansion to include the use of mineral resources and forestry products. Both the industrial and the regional patterns of environmental impacts are presented.

Pollution loadings are also sensitive to technologies used by plants and industries. Input/output analysis relies on fixed technological coefficients and constant returns to scale. In the case of paper production, an alternate pulping technology that uses waste paper is available. Production coefficients were developed for this technology in order to demonstrate the ability of the system to show the implications of different technologies.

The databases provide default values for coefficients that relate resource use and environmental indicators to output values. All of these environmental coefficients can be overwritten and changed as new information becomes available.

Furthermore, the coefficients that relate output and employment[18] to environmental indicators are subject can be changed. This flexibility is very important as changes in policy are likely to increase the efficiency of the environmental processes. Efficiency here is measured by lower emissions per unit of output. Investments in machinery to reduce pollution releases can result in lower pollutant loadings per unit of output for specific industries. The input-output model shows how these reductions may be counterbalanced by increases in pollutant loadings resulting from the firms that produce environmental protection equipment.

3.7 Summary

The LINK model is a substantive attempt to integrate the environment within a macroeconomic framework. Many compromises had to be made due to data shortages and insufficient evidence on the direction of causation between the environment and the economy which precluded operationalizing a more complex version of the model. Nonetheless, in its present form, the LINK model can be used to evaluate different scenarios and policy options and trace the impacts that these scenarios could have on the environment. Alternatively, environmental policies and programs have economic consequences and these can also be analyzed with the LINK model. In Chapter, 6 we postulate 5 scenarios and present selected results from the LINK model that demonstrate the utility and flexibility of the current version of model. Any modelling system that breaks new ground requires simplifying assumptions and the LINK model is no exception. In Chapter 7 we discuss the strengths and weaknesses of the current version of the model, pointing out the need to update and expand it together with suggestions on how to do so.

Glossary of terms and indicators used in the LINK model

The key terms and indicators included in the LINK model are as follows:

Employment, is the amount of labour time used in production, measured in person-years.

Gross provincial income (domestic product), is the total value of income/output of the economy which will be used for further processing in the economy. It includes the total value of income from payments to productive factors in the province. It represents the sum total of wages and salaries, interest payments, rent and profits.

Gross sales (or output) is equal to the total value of goods and services produced. It is also referred to as the value of shipments. It includes final as well as intermediate output.

---

[18] The two indicators are used interchangeably to underscore the fact that they are related to one another by fixed coefficients.

Labour income, equals the total value of wage and salary payments to employees. Labour income is used as a measure of changes in household (consumer) expenditures.

Taxes, are the direct and indirect income received by municipalities and the province from all sources.

The following 25 major industrial groups are specified in the LINK model:

- agriculture
- chemical products
- construction
- electrical products
- fabricated metals
- fishing
- food and beverage
- forestry
- furniture
- housing
- knitting and weaving
- machinery
- mining
- non-metal
- other
- paper
- petroleum products
- primary textiles
- primary metals
- printing
- services
- trade
- transportation equipment
- utilities
- wood

The environmental indicators and variables currently incorporated in the LINK model are as follows:

Air emissions (tonnes/yr):

- sulphur oxides (SO_x)
- nitrous oxides (NO_x)
- volatile organic compounds (VOC)

Energy use (terajoules/yr):

- coal
- crude oil
- natural gas
- electricity
- nuclear steam

Municipal solid waste types (tonnes/yr):

- old newspaper (ONP)
- fine paper
- boxboard
- old corrugated cardboard (OCC)
- mixed paper
- magazines
- telephone books
- glass containers
- plastics
- aluminum (containers)
- tinplate and steel (containers)
- used tires

- yard waste
- food waste
- wood waste
- construction/demolition waste
- disposable diapers
- foundry sands
- other wastes

Direct industrial water discharge contaminants (tonnes/yr):

- ammonia-N
- oil and grease
- total suspended solids (TSS)
- phosphorus
- cyanide
- phenolics
- copper
- lead
- zinc

4.

The environmental database

4.1 Overview

To model interactions between the economy and the environment, detailed information on the resources used and waste generated by each form of economic activity are required. Furthermore, quantitative and qualitative information on the current supply of resources is needed to quantify the constraints which define sustainable development. An important component of this study was the collection of these data for the Province of Ontario.

Relevant information was compiled in an environmental database from existing data available from various municipal, provincial and federal government agencies. The design, contents and overall status of this database are described below. Further details regarding the structure, processing and limitations of the data are provided in Appendix B.

4.2 Design and implementation

Environmental data were obtained from diverse sources and their original format was quite varied. All data have been entered into a geographic information system (GIS) with a common geographical framework. This section describes the nature of the data that have been assembled and the manipulations necessary to incorporate the data on the LINK model. Given that economic data were not available in GIS format, linking the environment to the economy within the LINK model was only completed at the county level. Counties were also aggregated into six regions as explained in section 3.6.

Structure of the database

The environmental database (EDB) comprises two separate databases: one consisting of resource use data, and the other, waste generation data. The data categories included are shown in Table 2.

Table 2 Environmental database categories

Database	Categories included
Resource use	Mining, forestry, agriculture, water use,
Waste generation	Air emissions, direct water discharge, hazardous industrial waste, municipal solid waste, municipal sewer discharges

These data were initially coded by sector and region using 4 digit SIC codes and two separate spatial formats: counties and sub-sub watershed basins. County boundaries are suitable lines along which to organize data to analyze linkages between the economy and the environment such as air emissions, production and disposal of hazardous and municipal waste, extraction of minerals and harvest of renewable resources such as forests and fish. However, to relate economic activity to factors such as water use, erosion, and the discharge of residuals into Ontario's lakes and rivers it is advantageous to organize data according to watershed basin boundaries. It is still our intention to operate LINK both at the county and watershed levels. This will have to wait until all the economic data are given GIS coordinates.

The GIS system

To make the contents of these databases as useful as possible, the resource use and waste generation data have been linked through a GIS using the location descriptions provided with the original data.

General status of the environmental database

Data have been collected in virtually every area targeted by the project team. Furthermore, virtually all of the information dates from the period between 1985 and 1991.[19]

---

[19] The soil information in the Land Potential Data Base is from the *1977 Soils of Canada Map*. However, given the relatively static nature of these data, the date of the data is not critical.

There are several shortcomings with the environmental data. These tend to fall into four categories.

1) It has not always been possible to obtain suitable data for the 1985 - 1989 period which correspond directly with the economic data. Consequently there are cases where the data are only available for one or two years of this period.

2) In some cases, gaps exist because of restrictions on dissemination of the information to protect the confidentiality of reporting companies. This tends to be a greater problem with the economic data but there are some cases with the environmental data.

3) Data on quality of inputs are not as readily available as data on quantities.

4) Data on stocks proven much harder to obtain than data on flows making it difficult to assess the impacts on resource use of changes in economic activity (see, section 3.6 for a discussion of these limitations).

4.3 Resource use

Resource use (including land) is a major linkage between the environment and the economy (ie. Linkage F in Figure 2). Resources are removed from the natural environment and enter the economic sphere as part of the production and consumption processes.[20] Data regarding these interactions are contained in the resource use database.

The direct use of resources from the natural environment takes place in a few clearly defined sectors of the economy. The major exceptions are water consumption by various industries (although some of this comes through the municipal supply system and does not represent direct withdrawal by the consuming sector) and land consumption. The resource use database focuses on four major primary resource-using sectors (mining, fishing, agriculture and forestry). Data on water use in each sector of the economy is also provided.

The LINK model incorporates the mining, agriculture and forestry data. Commercial fishing is not a major economic sector in the Ontario economy and was not included in this version of the model. Also, the model does not track land consumption (use) patterns according to economic activity. Much of the data necessary for this refinement to the model have been compiled in the environmental database.

---

[20] Land is not easily conceptualized in the same way as the consumption of other types of resources. The availability of land is, however, one of the key bio-physical constraints on the economic system. Data on the available supply and utilization of land is an important component of the data base.

For each sector, data were assembled regarding:

- the quantity of each resource used; and
- the value assigned to those resources once they enter the economy.

To provide a perspective on the physical flow of these data resources from the environment into the economy, data on the available stocks of each resource have been compiled. The current version of the LINK model, however, does not include a set of accounts to treat changes in resource stocks. The lack of resource stock accounts limit the ability of the LINK model to determine the optimal environment-economy relationship. As such the model provides a static comparison between different scenarios of the relationship. Once a complete set of data on stocks becomes available, LINK may be used to generate overall resource balances.

The status of each resource use data category is discussed below.

Mining

Overview

Data on the tonnages and value of metallic ores and industrial minerals mined in Ontario have been collected in machine-readable form for 1989.

Sources of information

Preliminary data on production from Ontario mines and quarries, aggregated to the county level, have been provided by the Ministry of Northern Development and Mines from their Screen Coordinated Resource Evaluation (SCORE) database. Ministry policy requires that data not be reported for counties with less than three establishments, whether or not the data are publicly available from other sources. Consequently, there are significant gaps in this database. These data are supplemented with information from a variety of other sources including the *Canada Mines Handbook* (published by the Northern Miner Press).

Stocks

Data on the known reserves of each metallic ore and industrial mineral in the province have been collected in electronic form through the MINSYS database available from Energy, Mines and Resources Canada.

Flows

Data on the value and quantity of metals and industrial minerals produced by county in 1989 have been compiled.

Forestry

Overview

Electronic data from the Ministry of Natural Resources have been collected for each of the forest management units (FMUs) throughout the province. For each FMU, data are available for cumulative annual increment, gross total volume and net merchantable volume. Additionally, harvested wood annual quantities are provided by FMU.

Sources of information

The Ontario Ministry of Natural Resources' Forest Industries Section, Forest Resources Branch and the Forest Products and Marketing Branch are the primary sources of this information.

Stocks

Electronic data for cumulative annual increment, gross total volume and net merchantable volume have been obtained.

Flows

Data from the Forest Resources Branch of the OMNR are not yet incorporated into the model.

Agriculture

Overview

Comprehensive data have been collected on the quantity and value of agricultural commodities produced in Ontario in 1988 and 1989. In some cases data are only available for multiple counties or at the regional level due to confidentiality restrictions.

The EDB also contains information on stocks of agricultural land in the province. However, quantitative data on the degradation of agricultural land associated with each crop are not available.

Sources of information

Statistics on the quantity and value of the production of each type of field crop and livestock for 1988 and 1989 were obtained from the Ontario Ministry of Agriculture and Food. These are published in *Agricultural Statistics for Ontario (Publication 20)*. Similar information on the production of seasonal fruits and vegetables was obtained from OMAF's *Seasonal Fruit and Vegetable Report*. Both of these documents also provide information on the area of land devoted to the production of each commodity and the yield for each crop.

OMAF has also provided data from the *Survey of Pesticide Use in Ontario, 1988*. This document provides detailed information on the use of pesticides and herbicides by type in Ontario. The

Fertilizer Institute of Ontario in Cambridge has supplied data on the use of fertilizers in Ontario by crop type and by county.

Data on the quantity and quality of agricultural land were obtained from the Land Potential Database for Canada (LPDB). The LPDB is a computerized information base created by the Land Resource Research Centre (LRRC) of Agriculture Canada containing data about soil, climate, physiography, land use, crop yields (actual and potential) and soil degradation. One problem with the LPDB is its low level of spatial resolution. The LPDB is referenced to the 755 map units on the Soils of Canada map which has a scale of 1:5,000,000. The GIS system was used to overlay the Soils of Canada Map on a map showing the county and sub-sub watershed basin boundaries.

More detailed information on soils and physiography has been identified in another LRRC publication, *Soil Landscapes of Canada: Ontario-South.*

Stocks

The EDB contains data on the acreage devoted to the production of each agricultural commodity and the yield from that land for each county in the province. Data are also available on the soil, climate and potential yield of all land in the province.

Flows

The EDB contains data on the values and quantities produced of the following agricultural commodities for 1988 and 1989:

- winter wheat
- oats
- barley
- mixed grain
- hay
- grain corn
- fodder corn
- dry white beans
- tobacco.

The most significant problem with the agricultural component of the EDB is the lack of information on land degradation in the province. Defined broadly, land degradation refers to any change in the soil that has a detrimental effect on either the agricultural productivity of that soil, the cost of production inputs, or the quality of the surrounding environment.[21] The four forms of land degradation of concern in Ontario are erosion, compaction, acidification and loss of organic matter. Of these, the most significant are soil erosion and compaction. Unfortunately, few data are available on either parameter.

The most widely used method of estimating soil loss due to erosion is the Universal Soil Loss Equation (USLE) which was developed by the US Department of Agriculture. This equation uses data on rainfall, soil characteristics, slope length and steepness, and agricultural practices to calculate potential long-term average annual soil loss at a particular site.

---

[21] This definition was adopted by Miller (1984).

A number of methodologies for applying the USLE in Canada have been proposed (Trant and Trepanier 1990; Shelton and Wall 1984; Trant 1989). However, no comprehensive analysis of soil loss in the province has been identified.

It should be noted that the EDB already contains some data which could be used to estimate the extent of land degradation. For example it contains data on annual soil water deficit, atmospheric deposition of substances affecting soil acidity, soil sensitivity to acid precipitation, pesticide use, rainfall, run-off and soil type.

Fisheries

Overview

Data have been collected on the value and quantity of fish caught commercially in the Great Lakes and major inland waters (the recreational fisheries was excluded due to incomplete data). However no significant data have been found on stocks of fish and this parameter was excluded from further analysis.

Water Use

Overview

The EDB contains data on water use in 1986 by the major (75-85% of the total) users of water in the province of Ontario. For the mining, manufacturing and thermal power sectors the resource use database contains data on the volume and source of water used, the volume discharged and the cost of water acquisition. Total discharge can be subtracted from total intake to yield a quantitative measure of net water use. For the hydro power generation sector, data on flow, spill, and power generation are available.

In the manufacturing, mining and thermal power sectors data are also available on the treatment technology used at each establishment, the purposes for which the water is used, and the destination of the discharge.

At the time of the completion of the study, data on water consumption for the residential and agricultural sectors was unavailable.

Sources of information

Data on industrial water use in Ontario were provided by the Water Planning and Management Branch of the Inland Waters Directorate of Environment Canada. The data were obtained from the 1986 Industrial Water Use Survey.

4.4 Waste generation

A second form of interaction between the environment and the economy occurs when wastes are generated as a result of economic activity are released into the natural environment (ie. Links G and I in Figure 2). Information regarding this form of interaction is captured in the waste generation database.

Air emissions

Overview

Data on the 1987 emissions of the following compounds from both point and area sources in Ontario are in the waste generation database:

- carbon monoxide (CO);
- nitrogen oxides (NO_x);
- sulphur dioxides (SO_2);
- total particulate matter (TPM); and
- volatile organic compounds (VOCs).

Data on the emissions in 1989 of the following toxic compounds are also included:

- polycyclic aromatic hydrocarbons (PAH);
- polychlorinated biphenyls (PCBs);
- dioxins;
- furans; and
- pesticides.

There may be some double counting in the database because certain quantities of some of the toxic compounds (eg. PAHs) may also have been measured as VOCs. However, the extent of this problem is thought to be small.

Sources of information

The former Air Resources Branch of the Ontario Ministry of the Environment and Energy has provided data from the *1987 Process Emission Estimates by Industrial Point Sources* and a draft version of the *Toxic Chemical Emission Inventory for Ontario and Eastern North America* (Ortech International 1990).

Water-borne discharges

Overview

A great deal of data has been collected on discharges and pollution loadings to surface waters in Ontario under the auspices of the *Municipal Industrial Strategy for Abatement (MISA)*. The main point sources of emissions to water are municipal sewage treatment plants (STPs) and industrial establishments which discharge directly to Ontario waterbodies. Data on emissions from both these types of sources in 1988 were collected and entered into the EDB. Sources of data on non-point sources have been identified.

Sources of information

Electronic data on municipal and industrial wastewater discharges were obtained from the former Water Resources Branch of the Ontario Ministry of the Environment and Energy. These data are published in the *Report on the 1989 Discharges from Sewage Treatment Plants* and the *Report on the 1989 Industrial Direct Discharges in Ontario*. The 1989 versions of both these reports have recently been released and have been entered into the EDB.

Other important sources of information which were identified but have not yet been collected in electronic form are the reports from the various Remedial Action Plan sites in the province. These reports contain useful summaries of the pollutants affecting specific waterbodies. They also contain data on emissions from non-point sources such as spills and run-off which are not captured in either of the point source databases described above.

Status of data

Data on discharges to Ontario waterbodies from both municipal STPs and industrial direct dischargers have been collected. For the STPs, data are available on concentration levels and loadings of BOD_5, suspended solids and phosphorus in 1988. Data are also available on loadings of a wide variety of pollutants (depending upon what type of plant is monitored) in the effluent discharged by most of the one hundred and sixty-seven industrial direct wastewater dischargers in Ontario in 1988. However, there are twenty-three dischargers for which it was not possible to calculate loadings because they only reported concentration levels of each pollutant and did not provide any data on total effluent flow.

Solid waste generation

Overview

Solid Waste generation has been divided into two categories: hazardous and non-hazardous waste.

Sources of information

Information on the generation of hazardous waste has been obtained from the Ministry of the Environment. The MOE Hazardous Waste Generator database lists all the generators of hazardous waste in Ontario and contains data on the quantities and type(s) of waste generated by each. The MOE Manifest Database contains information on the quantities and type(s) of hazardous waste that is shipped off-site.

The most recent estimates of per capita solid waste generation and recycling rates for each municipality in Ontario have been obtained from a recent study commissioned by OMOE (CH2M Hill 1991).

4.5 Resources at risk

The purpose of the resources at risk database was to identify, in physical terms, those resources that are "at risk" from environmental degradation in Ontario. However, the availability and applicability of the data for estimating the risk to resources in Ontario is limited. For example, to estimate the risks of damages to adjacent forest stands caused by a smelting operation requires data that are more spatially specific than are currently available. Data regarding the types and quantity of forest stocks are available for a forest management unit where an average forest management unit is in the range of 4 000 km^2. This is not an adequate level of resolution to address the site-specific issues associated with resources at risk. It is much more difficult to obtain and effectively integrate specific data on the mix of trees in the vicinity of the smelter, a dispersion model for airborne pollutants, soil, and hydrogeology data for the particular smelter and location. The resources at risk database is a crude surrogate for the biophysical interactions among generated wastes and the productive capability of the resource base (ie. Link H in Figure 2).

Given the constraints on the availability of data, it is difficult to derive the "risk" ranking system using a consistent evaluation framework. Consequently, this component of the project was not pursued as described in section 4.3.

4.6 Conclusion - updating the environmental database

The environmental data for this study was derived from dozens of different sources including private sector, provincial and federal data sources. These data sources, contact names and description of available data from these sources are maintained in a separate corporate data dictionary and described in greater detail in Appendix B. Update of the Environmental Database involves contacting the sources identified in the data dictionary periodically and acquiring the latest updates of the environmental data.

Given the diverse sources of data, much of the data required manipulation and formatting before it could be summarized and aggregated for input into the LINK model. It is planned that in the future the computer manipulations required for formatting these data be fully automated. For this study, the formatting and data operations were done manually.

A major drawback in the environmental data collected for this study was a lack of information on resource stocks or assimilative capacities of the air or water. Consequently, the LINK model could not be used to show the resource constraints that economic growth might come up against as indicators of sustainability, as described in section 2.3 of this project.

5.

The economic database

The economic data which underlie the Environment-Economy Linkages model are described in this Chapter. The following sections discuss the use made of standard input/output and other economic data; the basis for new technical coefficients for alternative technologies in the pulp and paper industry; the data describing the environmental protection industry; and the basis for spatial disaggregation of the economic data. The general structure of the model has been described previously in Chapters 2 and 3.

5.1 Standard economic inputs

The economy-environment linkages are articulated within a spatial general equilibrium framework. This framework has been described in Chapter 2. The economic core of this framework is an input/output system which tracks the activities of production, consumption and accumulation within a consistent accounting framework. These input/output accounts are one element of the Canadian System of National Accounts (SNA), which is maintained by Statistics Canada.[22]

Inflation to 1989 values

Although input/output data are provided on an annual basis for Canada, data for the provinces are provided only at five to six year intervals. In particular these data have only been developed for the years 1974, 1979 and 1984, with the next data planned for the year 1990 (but not available until late 1993). Thus the model is based on the 1984 data for Ontario. These data have been converted to 1989 values by following the "double-deflation" method which Statistics

---

[22] See, Statistics Canada cat. 13-589E for an overview of the CNSA and Statistics Canada Cat. 15-510 for the input/output system.

Canada uses to produce input/output data at constant prices (see, Statistics Canada Cat. 15-511). This procedure is based on industry price indices taken from Statistics Canada. These industry prices are used to calculate a consistent set of commodity prices based on the market shares derived from the output matrix. Subsequently, all commodity elements in the three matrices of the input/output system are converted to 1989 values, using these commodity price indices. Applying the industry price indices to the column totals of the input matrix gives 1989 values for industry outputs. After labour income, indirect taxes less subsidies and unincorporated business income have been converted to 1989 values, operating surplus (the last element in the value-added portion of the input matrix) is calculated as a residual. Detailed sources for the price and wage indices used to make this adjustment are described following.

Agriculture

The price index for Agriculture in Ontario was taken from *Index of Farm Prices for Agricultural Products*, Statistics Canada 62-003, Table 1: Farm Product Price Index, by Province (1981=100):

- Ontario September 1989 from September 1989 Vol. 44 No. 9 p. 3; and
- Ontario September 1984 from December 1986 Vol. 41 No. 12 p. 3.

Manufacturing

The manufacturing industry price indices were taken from Statistics Canada Cat. No. 62-011, *Industrial Product Price Indexes, by Industry & Industry Group*, (see, Table 3).

Resource production

The Fishing & Trapping, Logging & Forestry, Crude Petroleum & Natural Gas and Quarry & Sand Pit Industries price indexes were taken from *Industry Price Indexes* (Statistics Canada Cat. No. 62-011).

September 1989 indices are from Vol. 15 No. 9 September 1989 and September 1984 indices are from Vol. 14 No. 12 December 1988 (see, Table 4).

Construction

The Construction Price Index is the Toronto price index for Non-Residential Construction from *Construction Price Statistics*, Statistics Canada 62-007, Table 7.1 Outputs Price Indexes of Non-Residential Construction, 1981=100. 1989 Second Quarter from Second Quarter 1989 Vol. 5 No. 2 p. 38 and 1984 Second Quarter from Fourth Quarter 1988 Vol. 4 No. 4 p. 38.

Services

The Price Index for Services (third quarter 1989) was taken from *Canadian Economic Observer* Statistics Canada Cat. No. 11-010 (Vol. 2, No. 12 December 1989), Table 1-13 Implicit Price Indexes, Gross Domestic Product p6-15. The Price Index for Services (third quarter 1984) was taken from *National Income & Expenditure Accounts* Statistics Canada 13-001 (second quarter

Table 3 Mapping industrial product price indices

Aggregation level (M) industry number	September 1989 index page number	September 1984 index page number
8	70	70
9	71	71
10	72	72
11	72	72
12	72	72
13	72	72
14(a)	73	73
14(b)	73	73
15	73	73
16	73	73
17	74	74
18	75	75
19	75	75
20	76	76
21	76	76
22	77	77
23	77	77
24	79	79
25	80	80
26	81	81
27	81	81
28	82	82

1989 Vol. 37 No. 2), Table 21 Implicit Price Indexes, Gross Domestic Product p. 41.

For most service industries, with the exceptions of transportation and utilities, wage indexes for the corresponding industry were also used as industry price indexes. This procedure is justified by the fact that labour makes up the largest part of cost in these industries and that wages and prices in service industries as a whole have changed in almost identical proportions between 1984 and 1989. This procedure also has the advantage of using Ontario wage indexes rather than national price indexes for these industries.

Others

Various other price indices were taken from *Consumer Prices and Price Indices Quarterly*, Statistics Canada Cat. No. 62-010. The September 1989 indexes were taken from Vol.15 No.3 July-September 1989. The September 1984 indices were taken from Vol. 13 No. 4 October-December 1987. The page numbers of the indices used are presented in Table 5 and Table 6.

Table 4 Mapping raw material price indices

Raw material name	**September 1989 index page number**	**September 1984 index page number**
Fish	90	90
Wood	90	90
Ferrous materials	91	91
Non-ferrous	92	92
Coal	93	93
Crude mineral oil	93	93
Natural gas	93	93
Furs, hides & skins	89	89
Stone	93	93
Sand & gravel	93	93

Table 5 Consumer Price Index by city, major categories

Index (Toronto)	**September 1989 page number**	**September 1984 page number**
Transportation	67	67
Owner accommodation	67	67
Education	68	68
Health & personal care	68	68
Recreation	68	68
Food from restaurants	66	66
Food	66	66

Wages

Average weekly earnings (excluding overtime) for all employees for Ontario in manufacturing, forestry, mines, quarries and oil wells, construction, transportation, communication & other utilities, trade, finance, insurance & real estate, commerce and business & personal service industries were taken from *Employment, Earnings and Hours*, Statistics Canada Cat. No. 72-002. Wages for September 1989 are taken from Table 2.2: Estimated Weekly Earnings, Firms of All Sizes, by Industry, Provinces in Vol. 67, No. 9 September 1989, pp. 60-67. Wages for September 1984 are taken from Table 6: Weekly Earnings, by Industry, Provinces in Vol. 62, No. 10 October 1984, pp. 88-95.

Table 6 Consumer Price Index for Canada, major categories

Index (Canada)	**September 1989 index page number**	**September 1984 index page number**
Movies	37	37
Sports events	38	38
Spectator-entertainment performances	37	38
Alcoholic beverages	38	39
Traveller accommodation	31	31

Direct taxes

In addition to the input/output and price data described, the LINK model uses data to calculate direct tax rates to quantify impacts on tax revenues. Data on direct taxes by industry and direct taxes paid by households for Ontario in 1984 were obtained from *Provincial Economic Accounts Annual Estimates 1976-1987*, Statistics Canada Cat. No. 13-213 (February 1989). Wages, salaries and supplementary labour income, corporate profits before taxes, interest and miscellaneous investment income, accrued net income of farm operators from farm production and net income of non-farm unincorporated business including rent were taken from Table 1: Provincial Gross Domestic Product, p. 14. Direct taxes: from persons, from corporate and government business enterprises and from non-residents (withholding taxes) were taken from Table 3: Government Sector Revenue and Expenditure, p. 43 for total tax, from Table 4: Federal Government Revenue and Expenditure, p. 43 for federal taxes and from Table 5: Provincial Government Revenue and Expenditure, p. 72 for provincial taxes. Table 9: Direct Taxes-Persons, p. 130 provided Federal and Provincial Income taxes and Employer and employee contributions to public service pensions. Employer and employee contributions to unemployment insurance and to Canada Pension Plan and Employer contributions to workmen's compensation also were taken from this table.

Total Federal income taxes and provincial income taxes were taken from *Corporation Taxation Statistics*, Statistics Canada Cat. No. 61-208 (1985), Table 4: Federal and Provincial Income Taxes, By Major Industry Group, 1984 and 1985, p. 26. Taxable income by major industry for Ontario was taken from the same source, Table 5: Provincial Allocation of Taxable Income by Major Industry Group, 1984 and 1985, p. 39. Book profit before taxes, taxable income and income taxes by industry for Canada were taken from Table 8: Income Taxes by Industry, 1984 and 1985, pp. 64-69.

Energy use

The model also calculates impacts on energy use. Data on energy use in Ontario in 1984 were taken from *Quarterly report on energy supply-demand in Canada*, Statistics Canada Cat. No. 57-003 (1984-IV, Vol. 9, No. 4 Table 8B: Primary and Secondary Energy-Ontario-1984 Quarter 4 pp. 80-81). Indices are from Vol. 14, No. 12 December 1988.

5.2 New technical coefficients

The technologies that are used to extract materials from the environment, transform them into products, distribute them and dispose of them determine the nature of the linkages between the economy and the environment. Thus, at some point, an analysis of these linkages must address the question of which technologies are available, which are actually used and what possibilities may exist for changes in technology that may increase or reduce the material flows between the economy and the environment.

One of the advantages of input/output analysis is the highly disaggregated representation of economic activity that it offers. The sales and purchases of each commodity by each sector to and from each other sector and to final demand are included in great detail. Underlying these transactions is a technological sub-strata that determines the input requirements for each sector. Economists sometimes interpret the input/output coefficients for each sector as a production function for the sector. However, the technologies themselves are not revealed by these transactions since the transactions result from an aggregation of combinations of technologies employed at each of the establishments comprising a sector.

Most applications of input/output analysis assume that technical input/output coefficients do not change over time. Critics often point to this assumption as a key limitation of the methodology because it assumes that there will be no change in production technology within an establishment and no changes in the relative contribution of establishments using different technologies to the transactions of the sector as a whole. Neither of these assumptions are realistic in an analysis of economy-environment linkages over time. It would be desirable The for production technology coefficients to be incorporated as variable relationships rather than constants in the model.

There is no inherent requirement that production coefficients be constants in an Input/Output model. Historically, fixed coefficients have been employed primarily because of lack of data to produce functional production relationships or to estimate new coefficients each year. However, research has shown that, at least at the national level, production coefficients are reasonably stable over 5 to 10 years. It appears that the ‘average practice technology’ on which technical coefficients are based are slow to change even when a few existing establishments adopt new technologies, and old plants are closed to make way for new plants with new technologies.

There are several aspects of technology that present problems for empirically modelling linkages between the economy and the environment. First, extremely large numbers of technologies are in use at any one time and these have been selected from an even larger number of possible technologies available for use. Efforts to assemble a comprehensive database on technologies have met with only limited success.[23] The amount of data required for such a database is enormous and is well beyond the scope of the present study except in a highly selective fashion.

A second problem is that, once the possibility of employing different technologies is recognised, even in only a single sector, a decision rule of some kind is required that will select one technology or mix of technologies from those available. Failing this, it is sometimes possible to undertake sensitivity analyses using different technologies without attempting to predict which technology will be adopted and under what circumstances.

A third problem is that, if some allowance is made to incorporate changes in technologies, then the interconnected nature of an input/output model may require that successive iterations of the model be undertaken to arrive at an internally consistent set of inter-sectoral transactions. This is not impossible to do, but it does require a considerable increase in modelling time and effort. In this project, the implications for economy-environment linkages of changes in technology were explored in two ways. Alternative production technologies are incorporated in the model for the pulp and paper sector. Also, the environmental protection sector, which is distinguished as a discrete industrial sector in the model, can supply water and air pollution abatement technologies to the other sectors.

The next sections of this chapter describes the economic data that have been assembled for these two categories of technologies.

5.3 Production technologies

Alternative production technologies are incorporated into the model for the pulp and paper industry. With the increased attention being given to recycling, the pulp and paper industry is in the process of expanding its de-inking capacity. A typical version of this process has been incorporated in the input/output model as an alternative production technology.

This section provides an overview of the de-inking process.

De-inking

De-inking is a process designed to prepare pulp from waste paper products rather than using wood chips. This development has been mainly driven by four major forces: economics, legislation, consumer preferences and, in certain cases, limited forest resources. A process flow diagram of a typical de-inking process is shown in Figure 4. In operation, the waste newsprint (40% magazine and 60% news) is transported into the batch pulpers and then de-inked in the presence of chemicals, ie. surfactant, sodium silicate, DTPA and caustic soda. The ink is stripped from the waste paper in the pulper which is operated at consistencies ranging from 8 to 16%.

---

[23] The 'process encyclopedia' that was started by the Statistics Canada, Structural Analysis Division, as part of the development of SERF is one such example where an immense level of effort was expended to describe for various industrial sectors. The intention was to describe the technologies in detailed input/output terms suitable for inclusion in an input/output modelling environment.

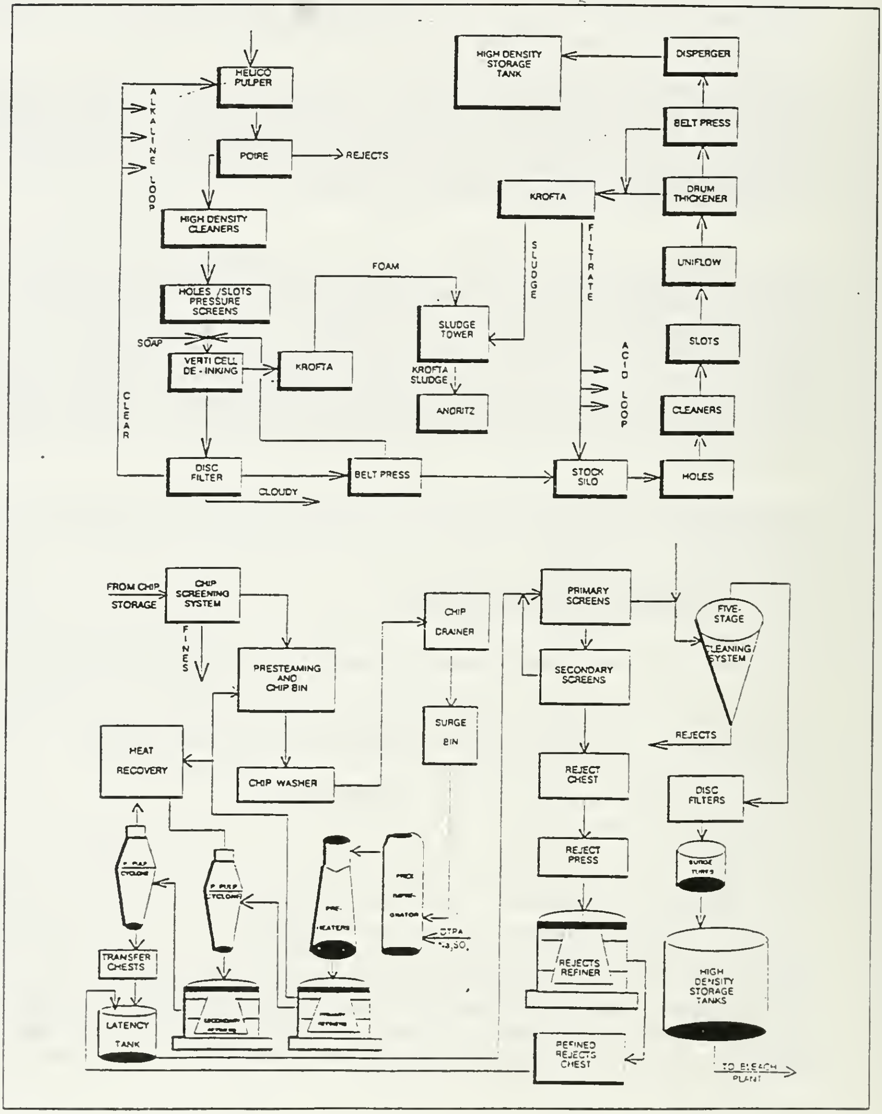


Figure 4 De-inking process

Each batch is pulped for about one hour at a temperature between 55° and 70°C and at a pH between 9 and 11.

After de-inking the pulp is discharged into a hold-up tank before it goes into subsequent continuous pulp cleaning operations. This pulp cleaning operation is subdivided into two loops: the alkaline loop and acid loop.

In the alkaline loop, the pulp from the hold-up tank passes through cleaners which remove heavy and light contaminants (eg. sand, wire, rag). After these cleaners, the pulp is de-watered in screw presses, raising its consistency to about 20% to 25%. In this step, about 90% of the black inky liquor is removed. The pulp cake from the presses is sent to the acid loop for further cleaning, while the black inky liquor is clarified and recycled to batch pulpers for heat and chemical recovery. This clarification step is carried out in a Krofta clarifier using the dissolved-air floatation technique.

In the acid loop, the de-inked pulp is first diluted and then screened. This is followed by a two-stage counter-current washing step with deckers and screw-press washers. The washing liquor from the deckers is also clarified in two Krofta clarifiers and reused in the washing operation.

After the acid loop the de-inked pulp may or may not be sent for bleaching; and then mixed with other fibre furnishes and sent to the paper machine. The sludges from both the alkaline and acid loop Krofta clarifiers are combined and pumped to the effluent treatment plant for further de-watering and disposal.

The operation is highly automated, requiring limited supervision but a considerable amount of power; 350 kWh/t is typical. The de-inked pulp is usually of a high quality with good brightness and cleanliness. There are no problems on paper machines with stickies even when using 50% de-inked pulp (DIP).

5.4 Abatement technologies

This section describes the database that has been assembled on air and water pollution abatement technologies considered within the environmental protection sector of the LINK model.

Air pollution abatement technologies

Information on air pollution abatement technologies, their cost and effectiveness, was assembled in a study for the Ministry of the Environment (Senes 1990). This study brought together information for 43 individual 4 digit SIC categories from the following sectors:

- open pit mining
- food industry
- pulp and paper and allied products
- iron and steel industry
- foundries
- non-ferrous smelters and refineries
- automotive industry
- inorganic chemical manufacturing
- petroleum refineries
- asphalt paving
- petrochemical product manufacturing
- electrical power generation
- waste disposal facilities

- municipal incinerators.

Table 7 Particulate abatement and gas and vapour abatement air pollution abatement technologies

Particulate abatement technologies	**Gas and vapour abatement technologies**
• inertial separators	• absorption
• wet collection devices	• adsorption
• fabric filters (baghouses)	• chemical reaction
• electrostatic precipitators	• incineration
• others (precleaners)	• condensation

SOURCE: SENES 1990.

The air pollution abatement technologies for which costs and performance data were collected in Senes (1990) are divided into two main categories, particulate abatement and gas and vapour abatement, and several sub-categories (Table 7). A database has been assembled which includes the following fields:

- 4 digit SIC
- manufacturing process
- number of plants
- number of employees
- annual production (tonnes)
- existing abatement technology
- abatement technologies for 3 more stringent levels of abatement
- emission factors for existing abatement technology (kg/t)
- emission factors for 3 more stringent levels of abatement (kg/t)
- capital cost for more stringent abatement technology
- operating costs for more stringent abatement.

Water pollution abatement technologies

A recent study undertaken for the Ministry of the Environment assembled a considerable amount of information on water pollution abatement technologies (VHB 1991). The purpose of the study was to establish a database on the emission of pollutants and abatement technologies relevant to the MISA program and to provide a methodology for estimating the costs of compliance for the following sectors:

- petroleum refining
- organic chemical manufacturing
- iron and steel
- metal mining and refining
- industrial minerals
- electric power generation
- inorganic chemical manufacturing
- metal casting
- metal finishing.

Efficiency and cost data were assembled for the following generic abatement technologies:

- activated sludge
- chemical oxidation
- chemical reduction (chromium reduction)
- cooling tower
- denitrification
- dissolved air flotation
- granular activated carbon adsorption
- granular media filtration
- gravity oil separation
- ion exchange
- nitrification (new)
- powder activated carbon
- primary clarification
- sedimentation with lime addition
- steam stripping
- air stripping
- neutralization
- aerated lagoons
- nitrification (upgrade).

These generic technologies were combined into several feasible ‘plans’ for the plants in each sector. This database has been incorporated into the LINK model. Information on the following fields is included:

- 4 digit SIC
- plant name
- plant location
- products
- existing abatement technology
- more stringent abatement plans
- existing emissions (flow and concentration)
- more stringent abatement technologies
- removal efficiencies for abatement technologies
- removal efficiencies for abatement plans
- capital cost for abatement technologies
- operating costs for abatement technologies
- capital cost for abatement plans
- operating costs for abatement plans.

5.5 Environmental protection industry database

A major departure from conventional input/output models is the inclusion of the final demand sectors in the “Make” matrix. In the LINK model, households and institutions—as well as industries—produce waste. In addition recycled material and recyclable waste are distinguished from other commodities. Also important is the prominent role given to waste management services and environmental protection industries.

The environmental protection industry (EPI) represents a constellation of several industries involved directly in handling liquid and solid waste, recycling, air and water pollution control equipment or indirectly as providers of treatment chemicals, consulting engineers, laboratories, training and biotechnological services. Together they accounted for 28,000 jobs and 1700 firms in Ontario in 1987 (Woods Gordon 1989.)

Protecting the environment is an increasingly important objective of government, whether through regulation or through the indirect use of economic instruments. Industries, institutions and households are expected to reduce the use of nonrenewable resources and the emission of pollutants, and to recover, reuse and recycle waste materials.

It is difficult to gauge the importance of EPI activity in any precise way. The current economic accounts are not organized in a manner that would allow the grouping of this activity in any meaningful and useful way. Most of the activities identified above are lumped into their generic sectors and the tracking of environmental services and products is left to the interested researcher.

The input/output sectors were aggregated in a way that separates EPI activities into special sectors. This entailed several adjustments to the standard accounting framework. The input/output structure of the Ontario economy has been adjusted to allow for the production and treatment of municipal waste. A distinction has been made between recyclable and recycled products. No distinction between virgin products and products that are produced from recycled materials has been made on the grounds that this distinction is largely irrelevant to the final consumer; but a distinction has been made between recycled and primary materials as inputs into production (eg. pulp from waste paper or secondary fibre and pulp from newly cut roundwood).

Another change made to the model is to allow the household and the institutional sectors to appear as producing sectors of waste and recyclables. The recycling activity was distributed over the various stages in the production circuit that characterize it. Allowance has been made for transfer stations, sorting stations, and de-inking industries, it to appear separately as producers of unique products and services and as absorbers of resources and technology. This reformulation changed the structure of the prevailing accounting system. It is now possible to separate waste treatment by the sector delivering and using it. In this way what used to be final output by appearing under the municipal government activity is appropriately allocated to the activity using it (ERL and VHB 1990).

A similar adjustment has been made to allow the EPI to appear separately and uniquely. For this to be accomplished,it was necessary to re-arrange the input/output structure to allow the grouping of the EPI activities together and to net them out from where they are currently included. This arrangement serves several purposes. First, it shows the EPI as a clearly identified activity that can be monitored and studied in relation to the other sectors and to the environment. Secondly, EPI is identified as a sector delivering a unique service or product directly linked to the objective of cleaning and protecting the environment. Thirdly, to the extent that this activity is unique and uses different technologies from those used by other similar activities not engaged directly in environmental protection, it is useful to see its operations isolated from other activities and grouped together separately. Fourthly, environmental policies are likely to impact this activity in a very direct and significant way. It is useful to be able to gauge the impact of different environmental policies on this sector. Fifthly, it is believed that Ontario may have developed an early comparative advantage in this activity. Separating EPI from all other sectors facilitates research into the likely consequences of increased export activity in this sector.

5.6 Spatial disaggregation

The original regional input/output model developed by ERL for Ontario operates at the county level. This is a suitable level of spatial resolution for analysing many of the linkages between the economy and the environment: air emissions, the production and disposal of hazardous and municipal waste, the extraction of minerals and exploitation of renewable resources such as forests and fish. However, to relate economic activity to water use and the discharge of residuals into Ontario's lakes and rivers it is advantageous to configure the input/output model at the sub-sub watershed level.

Two versions of the input/output model are being developed with different spatial dimensions: county and watershed. These configurations define a rudimentary system of geographically coding the data and related analytical results. One possibility, that was constrained by the available data, was to geographically code all of the economic data used to estimate the input/output coefficients. This would have allowed a Provincial input/output model to be re-estimated for any spatial configuration that could be constructed from the geographically coded data. Ultimately, a fully geo-referenced databases with a correspondingly flexible input/output model structure will provide the opportunity to explore a wide range of economic and environmental policy questions.

6.

Environment—economy linkages under alternative scenarios

Linkages among environment effects and economy activities are complex. Even the initial prototype model developed in this study reveals the intricate connections that are not easily discerned without involved analysis. Direct economic consequences give, at best, a partial view of the potential effects of economic actions on the environment. In this Chapter, the quantitative responses of the environment and the economy to five hypothetical scenarios are analysed. These scenarios should not be viewed as predictions or forecasts of likely futures but a set of assumptions and conditions whose consequences are quantified by using the LINK model. The scenarios are intended to provide insights into the dynamics and utility of the LINK model.

Five scenarios are developed and compared to a base case calibrated for the Ontario economy using the LINK model.

6.1 Description of the scenarios

Base case

The base case is developed using the actual data on final demand categories for 1990 in conjunction with Ontario input/output tables for 1984. Prices are revised upward from 1984 to 1990 by using industry selling price indices. The exogenous part of final demand (investment in machinery and construction, government expenditures and exports) were assigned their 1990 values to derive employment, Gross Provincial Income (GPI), taxes and environmental effects for the base case. In order that the base case approximates reality, deviations of model results from actual figures were calibrated to the recorded values. Once these deviations were adjusted, the model replicated the actual situation in 1990. Each of the other scenarios are constructed using the calibrated base case version of the model. A Glossary of Terms and Indicators used in the model and the model results is found in Chapter 3.

Scenario 1 — Base case Ontario economy in 1990

The first scenario accepts the real historical growth rates of sectoral output in Ontario between 1981 and 1989 as the basis for projecting output between 1989 and 1990. In other words, this scenario examines the implications of the economy continuing to grow between 1989 and 1990 at the same rates of growth as those observed between 1981 and 1989. Growth rates per sector were imposed on the system in order to generate the observed rates of growth in overall macroeconomic variables in Ontario over the period 1981-1989. The environmental consequences of an economy growing at its real historical growth rates were also calculated.

Scenario 2 — export led growth

Export led growth is the second scenario. It duplicates the base case and adds a 5% growth in exports. All other exogenous variables remain unchanged from their base case values. This scenario is conceived against a background of burgeoning exports as the Canadian dollar exchange value continues to decline against the US dollar. It is also interesting to gauge the impact on the economy and the environment of a lopsided recovery with exports playing the major propulsive force in the economy.

Scenario 3 - substitution of plastic for steel

Plastic is postulated to replace steel in the making of glass and metal containers and steel and aluminum cans. An aggressive substitution plan is specified whereby $1 billion in sales of plastic products replaces $1 billion in sales of steel.

Scenario 4 - contaminant reductions by pulp and paper mills

Programs to reduce pollutants require capital and operating expenditures. The magnitudes and effectiveness of these programs vary with the amount of money to be spent or with the pollution reduction targets that are adopted. In this scenario, about $1 351 million in capital is assumed to be spent on pollution control equipment by about 26 pulp and paper mills in Ontario to achieve a reduction of eight percent in ammonia discharges, 42% in total phosphorus loadings and 86% in total suspended solids (TSS) per year. A total of $63 million would have to be spent yearly on operating the abatement technologies.

Scenario 5 - contaminant reductions by metal mines

In this final scenario, abatement technologies are postulated to be applied at about 30 mines in Ontario to achieve water-borne contaminant loading reductions of 31% in TSS, 25% in total cyanide, 72% in copper, four percent in lead and 83% in zinc. These technologies were estimated to cost about $172 million in capital and $16 million in yearly operating expenses.

Cost and pollutant reduction estimates for the pulp and paper and the mining sectors used in Scenarios 4 and 5 were developed by the Economic Services Branch of the Ministry of Environment and Energy and are summarized in Table 8.

Table 8 Estimates of costs and percent reductions by sector based on the maximum technically achievable level of abatement

Sector	Capital cost ($M)	Operating cost ($M)	Number of plants	"Conventional" contaminants				Non-persistent toxic contaminants		Metal contaminants			REIM number
				Ammonia-N (t/a)	Oil and grease (t/a)	Total phosphorus (t/a)	TSS (t/a)	Total cyanide (t/a)	Phenolics (4AAP) (t/a)	Copper (t/a)	Lead (t/a)	Zinc (t/a)	
Pulp and paper	$1 351.0	$63.3	27	335.0									10
Initial loading				b.	ND	264.0	36 400.0	ND	ND	ND	ND	52.1	
Final loading				b.	ND	153.0	4 970.0	ND	ND	ND	ND	0	
% reduction				8%	0%	42%	86%	0%	0%	0%	0%	0%	
Metal mining	$172.2	$15.5	30										4
Initial loading				658.5	277.9	ND	1 784.4	33.8	2.3	35.8	3.0	30.6	
Final loading				658.5	277.9	ND	1 238.0	25.2	2.3	10.2	2.9	5.1	
% reduction				0%	0%	ND	31%	25%	0%	72%	4%	83%	

Source: Economic Services Branch, Ontario Ministry of Environment and Energy

NOTES: ND - Not detected or below the detection limit.
a - Percentage reduction based on nitrate + nitrite (derivative of Ammonia-N).
b - Percentage reduction based on TKN (derivative of Ammonia-N).

6.2 Results

Table 9 presents base case data on the economy together with the environment and results for the five scenarios.[24] Economic variables include employment, GPI, taxes and imports. The model produces a additional results which are detailed in Appendix E. Environmental indicators presented include: water intake and discharge, emissions by three types, energy by five different fuels, solid waste by 19 different types and wastewater contaminants by nine contaminants. As noted, additional environmental outputs are generated by industry and region (county).

Table 10 presents the numbers from Table 9 as percentages relative to the base case. The percentages can be used to derive elasticity estimates linking the economy to the environment as will be indicated below.

Were the economy to continue to grow at its historical rates of growth without any technological adjustments, more output and employment, as well as more pollution, would be generated. Water and energy consumption would increase also. None of these results is surprising. What is revealing is that economic growth does not trigger a commensurate increase in waste or demand for natural resources. All other rates of growth are slightly lower than that of GPI. Differences are not large but evident.

Table 9 Environment-economy indicators under alternative scenarios

Indicators	Base case	Base case economy in 1990	Export led growth	Substitution ($1B steel to plastic)	Metal mining contaminant reduction	Pulp & paper contaminant reduction
Gross provincial income (GPI) ($billion/a)	277.4	302.3	283.9	277.4	277.6	279.0
Employment (million person years/a)	4.59	4.99	4.72	4.59	4.59	4.62
Imports ($billion/a)	100.4	109.3	103.3	100.3	100.5	101.1
Taxes ($billion/a)	76.3	85.3	78.1	76.3	76.3	76.7
Federal	43.6	49.7	44.7	43.6	43.7	43.9
Provincial	22.9	24.9	23.4	22.9	22.9	23.0
Local	9.8	10.7	10.0	9.8	9.8	9.8
Energy (terajoules/a)	3 519 820	3 796 421	3 631 591	3 497 780	3 522 348	3 539 201
Oil	1 818 309	1 948 586	1 872 101	1 818 656	1 819 190	1 825 093
Coal	536 382	580 651	555 473	518 375	536 928	540 662
Hydro	218 276	237 227	225 388	217 241	218 470	219 720
Nuclear	48 581	52 749	50 221	48 887	48 608	48 781
Natural gas	898 272	977 208	928 407	894 621	899 152	904 946

---

[24] Regional results from the LINK model are presented in Appendix E.

Table 9 Environment-economy indicators under alternative scenarios

Indicators	**Base case**	**Base case economy in 1990**	**Export led growth**	**Substitution ($1B steel to plastic)**	**Metal mining contaminant reduction**	**Pulp & paper contaminant reduction**
Water (million m^3/a)						
Intake	1 594 640	1 735 208	1 643 065	1 593 050	1 595 630	1 601 802
Discharge	1 578 673	1 717 835	1 626 612	1 577 098	1 579 653	1 585 764
Air emissions (t/a)	763 466	828 618	787 235	761 184	764 096	767 185
SO_x	547 158	593 980	564 018	545 796	547 573	549 715
NO_x	199 959	216 983	206 315	199 213	200 144	200 946
VOC	16 349	17 655	16 902	16 174	16 379	16 523
Solid wastes (t/a)	15 531 508	16 865 033	16 400 519	15 989 285	15 991 838	16 065 305
Old newspaper	498 004	540 762	525 868	512 682	512 764	515 120
Fine paper	1 042 697	1 132 222	1 101 037	1 073 429	1 073 600	1 078 533
Boxboard	964 883	1 047 728	1 018 870	993 322	993 481	998 045
Corrugated cardboard	1 276 136	1 385 704	1 347 538	1 313 749	1 313 959	1 319 995
Mixed paper	233 439	253 482	246 501	240 320	240 359	241 463
Magazines	373 509	405 572	394 401	384 512	384 573	386 340
Telephone books	15 562	16 898	16 433	16 021	16 024	16 098
Glass containers	171 189	185 887	180 767	176 235	176 263	177 073
Plastics	295 690	321 077	312 234	304 405	304 454	305 853
Aluminum cans	46 687	50 696	49 300	48 064	48 072	48 293
Tin plate steel	77 813	84 494	82 167	80 107	80 119	80 488
Used tires	249 002	270 381	262 934	256 341	256 382	257 560
Yard waste	326 815	354 875	345 101	336 448	336 502	338 048
Food waste	1 416 200	1 537 794	1 495 438	1 457 941	1 458 174	1 464 873
Wood waste	4 186 350	4 545 788	4 420 581	4 309 737	4 310 425	4 330 228
Demolition waste	373 503	405 572	394 401	384 512	384 573	386 340
Diapers	15 562	16 898	16 433	16 021	16 024	16 098
Foundry sand	1 027 134	1 115 323	1 084 603	1 057 408	1 057 576	1 062 435
Wastewater discharges (t/a)	268 405	291 931	278 134	266 448	267 460	156 696
Ammonia-N	9 670	10 479	10 026	9 394	9 679	9 637
Oil & grease	7 387	8 006	7 652	7 120	7 394	7 437
Total suspended solids (TSS)	246 913	268 646	255 867	245 530	246 058	135 601
Phosphorus	1 403	1 520	1 456	1 409	1 403	956
Cyanide	435	466	451	411	420	439
Phenolics (4AAP)	387	411	399	383	387	391

Table 9 **Environment-economy indicators under alternative scenarios**

Indicators	Base case	Base case economy in 1990	Export led growth	Substitution ($1B steel to plastic)	Metal mining contaminant reduction	Pulp & paper contaminant reduction
Copper	85	92	88	84	38	86
Lead	94	122	97	92	93	94
Zinc	2 033	2 190	2 098	2 024	1 989	2 055

NOTE: Environmental indicators organized by regions are presented in Appendix E.

Table 10 Environment-economy indicators: deviations from the base case

Indicators	Base case	Historical growth rates (% change)	Export led growth (% change)	Substitution ($1B steel to plastic) (% change)	Metal mining contaminant reduction (% change)	Pulp & paper contaminant reduction (% change)
Gross provincial income (GPI) ($billion/a)	277.4	9.0%	2.4%	0.0%	0.1%	0.6%
Employment (million person years/a)	4.59	8.6%	2.8%	0.0%	0.0%	0.7%
Imports ($billion/a)	100.4	8.9%	2.9%	-0.1%	0.1%	0.7%
Taxes ($billion/a)	76.3	11.9%	2.4%	0.0%	0.1%	0.6%
Federal	43.6	13.9%	2.5%	0.0%	0.1%	0.6%
Provincial	22.9	8.9%	2.4%	0.0%	0.1%	0.6%
Local	9.8	9.5%	2.2%	0.0%	0.1%	0.5%
Energy (terajoules/a)	3 519 820	7.9%	3.2%	-0.6%	0.1%	0.6%
Oil	1 818 309	7.2%	3.0%	0.0%	0.0%	0.4%
Coal	536 382	8.3%	3.6%	-3.4%	0.1%	0.8%
Hydro	218 276	8.7%	3.3%	-0.5%	0.1%	0.7%
Nuclear	48 581	8.6%	3.4%	0.6%	0.1%	0.4%
Natural gas	898 272	8.8%	3.4%	-0.4%	0.1%	0.7%
Water (million m^3/a)						
Intake	1 594 640	8.8%	3.0%	-0.1%	0.1%	0.4%
Discharge	1 578 673	8.8%	3.0%	-0.1%	0.1%	0.4%
Air emissions (t/a)	763 466	8.5%	3.1%	-0.3%	0.1%	0.5%
SO_x	547 158	8.6%	3.1%	-0.2%	0.1%	0.5%
NO_x	199 959	8.5%	3.2%	-0.4%	0.1%	0.5%
VOC	16 349	8.0%	3.4%	-1.1%	0.2%	1.1%
Solid wastes (t/a)	15 531 508	8.6%	5.6%	2.9%	3.0%	3.4%
Wastewater discharges (t/a)	268 405	8.8%	3.6%	-0.7%	-0.4%	-41.6%

NOTE: Total quantities of each indicator by scenario are presented in Table 9.

These results suggest that, over time, the economy has adjustment mechanisms that bring about a deviation from unitary elastic changes between the economy and the environment. Should this trend continue, economic growth may increasingly be separated from generating equal changes in the environmental variables. Oil demand is shown to rise less proportionately than natural gas demand under the historical scenario. The economy is increasingly improving the efficiency with which it is using oil and there are apparent shifts away from oil-intensive activities.

The current recession has derailed the economy from its historical growth path. The export growth scenario, triggered primarily by a major and significant real depreciation of the Canadian dollar, and perhaps by freer trade arising from the *Canada-United States Free Trade Agreement*, is the only engine of growth in activity in the economy in the scenario. In the export-led scenario, the economy is given a five percent real growth in exports keeping other exogenous variables at their 1990 magnitudes. The results in Tables 9 and 10 indicate that income grows by about two percent, employment by almost three percent and imports by about three percent, suggesting that overall economic growth is inelastic with respect to export growth. Surprisingly, the opposite is true about most environmental indicators. Energy consumption increases (about three percent) exceed that of output increases; coal consumption alone increases by almost four percent. Water consumption growth rates are also higher than those of GPI, but fall short of the growth rates for energy consumption. Solid waste components, however, appear to grow faster than even the exports themselves (almost six percent). Wastewater contaminants also grow at rates faster than output or employment growth but fall short of the original increase in exports.

Perhaps the most interesting results emerge from scenario 3 where the economy is shocked with a $1 billion reduction in the demand for steel and an increase by $1 billion in the demand for plastic. The overall change in the macroeconomic variables is minimal. Only imports show a small change. But changes in some environmental indicators are large compared with other scenarios. With the exception of solid wastes, all other environmental indicators show decreases in magnitude. The most pronounced decreases are in the demands for energy (primarily in the demand for coal) which is a principal input in steel making. Significant decreases are also registered in the emissions of VOCs. All of the contaminants discharged into the water systems of the province also decrease except for phosphorus.

Scenarios 4 and 5 depict the consequences of investment in environmental protection activities and equipment to reduce contaminant discharges from the pulp and paper and mining industries. The capital costs and operating costs of these contaminant reduction programs were added to the base case environment-economy profile and the base case loadings of contaminants in the targeted industries were reduced as shown in Table 8.

In the metal mining contaminant reduction scenario, capital expenditures total $172 million with over $15 million per year in operating expenses for about 30 mine sites. These expenses made little difference to the overall macroeconomic operation of the Ontario economy. Changes in the consumption of resources and emissions are also small. Changes in **total** discharged wastewater contaminants were estimated as follows: copper discharges fall by 55%; cyanide by over three percent; and zinc by about two percent. Interestingly, these reductions in contaminant discharges are smaller than the direct reductions estimated to be achieved in each industry (see Table 8) by the postulated contaminant reduction programs. The reason that **total** final reductions from all sources are smaller than the reductions achieved in each of the two industrial sectors is that capital and operating expenditures result in increases in pollutant discharges from the firms and industries that produce pollution abatement equipment. Of course, capital expenditures are not likely to be made every year so that, in the future, only operating expenditures would be made and would generate indirect pollution from other sectors. In this case, reductions in contaminants would have to be measured against the situation of no change in the environmental coefficients. In other words, the present contaminant reduction scenarios understate the potential effectiveness of the respective contaminant reduction programs.

The estimated capital cost of the pulp and paper industry program (scenario 4) is about $1 350 million and the operating expenditures exceed $63 million. The influence of these expenditures on the economy is more pronounced than those associated with the metal mining program (scenario 5) because the values for the pulp and paper scenario are much larger than the mining scenario. Employment, GPI and imports all increase by about 0.7%. Emissions increase at a higher rate than the direct reductions targeted in the scenario, whereas water use rises by a lower rate. Some components of energy consumption increase at a higher rate while others at lower rates. The larger changes are in contaminant discharges. Large decreases in ammonia, TSS, and phosphorus are estimated (see Appendix E for detailed scenario results). Again, some increases are observed in oil and grease, phenolic, cyanide, copper and lead. However, these increases are the result of high initial capital expenditures. If only operating expenditures were considered, the magnitudes of the reductions or increases in the environmental indicators would be lower. In fact, to account appropriately for the total environmental impact of both scenarios, model results should be generated for a time frame over the entire useful life of the pollution control technologies utilized. Such a profile would account for both the accumulated reductions in contaminants released into the environment and for the corresponding annual operating expenditures for pollution control to achieve these reductions over the specified period of time.

7.

Model analysis

The environment-economy linkages model provides a basis for examining the environmental effects of economic activity and environmental policies on economic activities. The initial prototype version of the model described in this report could be improved and expanded in a number of ways. The strengths and limitations of the model are discussed and recommendations for future refinements are presented in this chapter. In addition, potential applications of the model are described to illustrate its potential usefulness.

7.1 Strengths

An important strength of the model is the formulation of quantitative links between economic activity and the environment within an input/output modelling framework which can be used to estimate both economic and certain environmental effects of program and policy changes. The LINK model integrates the environment within a macroeconomic framework. Compromises had to be made because of data shortages and insufficient evidence on the direction of causation between the environment and the economy precluded the possibility of operationalizing a more complex version of the model. Nevertheless, LINK is capable of assessing the economic and environmental implications of both economic and environmental policy scenarios. In Chapter 6, five scenarios were postulated and their results were generated using LINK in order to demonstrate the utility and flexibility of the model.

The model structure operates at both the industry and regional levels. The industry level is necessary to capture varying environmental effects across industries. The regional framework is necessary because environmental impacts are spatially specific. As a result of this structure, the model not only allows estimation of certain environmental impacts but it also allows economic consequences to be estimated for the provincial economy as a whole and for specific industries.

The environmental effects which are identified in the model include the use of renewable resources (ie. air and water) non-renewable resources (ie. energy) and the generation of non-hazardous residential, industrial, commercial and institutional solid waste and discharges of hazardous industrial liquid and solid wastes to water systems. Air emissions of NO_x, SO_x and VOCs are broken down by both industry and region. Industrial water intake and discharge are also broken down by industry and region. Energy use is calculated by primary energy type in both physical and energy units. Residential and IC&I solid waste generation by 19 types of waste is also identified, as well as industrial pollutants discharged into the water system, by industry and region.

Environmental data were derived from dozens of different sources including private sector, provincial and federal data sources. These data sources, contact names and description of available data from these sources are maintained in a separate corporate data dictionary. Update of the environmental database involves contacting the sources identified in the data dictionary periodically and acquiring the latest updates of the environmental data.

An important part of the assessment of sustainable development is the ability to project the likely economic and environmental impacts of a given configuration of the economy into the future. Since final demand components in 1990 drive the model, it is possible to gauge the sensitivity of the economy to environmental constraints or the environmental impacts of different economic performance levels.

The model has the added advantage of displaying all the environmental coefficients of the system and allowing the user to change each coefficient. This permits testing the sensitivity of the system to different economic or regulatory schemes that aim at changing the pattern of environmental activities.

In this project, the implications for economy-environment linkages of changes in technology were explored in two ways. Alternative production technologies are incorporated in the model for the pulp and paper sector. Also, the environmental protection sector, which is distinguished as a discrete industrial sector in the model, can supply water and air pollution abatement technologies to the other sectors.

Although the model does not allow for a closed loop system where the economic consequences of environmental impacts are fully tracked (ie. in terms of reduced supplies of natural resources), it provides a flexible (though static) modelling framework for dealing with issues of sensitivity of the environment to different economic profiles and for evaluating economic and environmental impacts of alternative economic projections.

A major departure of the LINK model from other input/output models is the inclusion of the final demand sectors in the "Make" matrix. In the LINK model, households and institutions—as well as industries—produce waste. In addition recycled material and recyclable waste are distinguished from other commodities. A similar adjustment to conventional I/O models was made to allow the EPI to appear separately and uniquely, illuminating the prominent role given to waste management services and environmental protection industries.

The LINK model is flexible enough to provide a workable framework that can be extended and modified. For example, data regarding the stock of environmental resources incorporated into the model would extend the analysis to include the impacts of chosen path of economic activity on the quality and quantity of these stocks, thus indicating the sustainability of the chosen level and type of economic activity. The intention of this project was to begin with a general prototype that is amenable to these extensions.

7.2 Limitations

The limitations of the model include both data problems and structural deficiencies. The economic data were derived primarily from materials published by Statistics Canada. Their reliability is high and these data satisfy accepted accounting identities and procedures. While the environmental data set is also derived from reliable sources and published materials, its novelty and the difficulty of aggregating the various components to correspond exactly to the input/output format introduced a greater margin of error. Furthermore, it was not possible to obtain reliable data on stocks of minerals, wood and water. This difficulty precluded our ability to maintain a count of cumulative absorption of resources and the withdrawal of assets. Such accounts are essential to the ability to measure reductions of vital resource stocks (eg. solar radiation, surface area, genetic material, all minerals, etc.). Specifically, the shortcomings of the environmental data fall into four categories: i) limited suitable data for the 1985 - 1989 period which correspond directly with the economic data; ii) data gaps because of restrictions on dissemination of the information to protect the confidentiality of reporting companies; iii) Data on quality of inputs are not as readily available as data on quantities; and iv) data on stocks proved much harder to obtain than data on flows making it difficult to assess the impacts on resource use of changes in economic activity.

As well, all sectoral and industrial data could not be converted into a GIS format. This shortcoming precluded overlaying counties on watersheds and vice versa. As well, the lack of geographically coded economic data made it impossible to complete the analysis of STP influent and effluent rates and to incorporate this component of the waste stream into the model. Ultimately, a fully geo-referenced databases with a correspondingly flexible input/output model structure will provide the opportunity to explore a wide range of economic and environmental policy questions.

There are several problems relating to the model structure and its assumptions. Some of the general difficulties associated with the use of fixed coefficients and input/output models apply to our model. The issue, however, is the lack of other credible alternatives. Computable general equilibrium models (GEM) do not correspond widely to any particular data set and are fraught with as many, if not more, assumptions as linear fixed coefficient models. Whatever advantage price sensitive elasticities give the CGE models is generally lost to the fact that only intercepts are made to fit actual data, so that values for the price elasticities have to be taken from other sources. As a result the forecast generated by these models are very sensitive to the values assumed for the elasticities. As a result, these models seem to generate unrealistic forecasting results. Input/output models do allow the direct introduction of structural change because technologies are specified explicitly. A partial attempt was made to introduce different technologies and allow for choice of technologies within LINK. The operational system embedded in LINK has not fully succeeded in introducing this flexibility into the current system.

There are also some difficulties in incorporating all the socio-economic and environmental aspects that are deemed vital to a full linkage model. One of the major socio-economic limitations is the failure to include endogenously population growth and distribution in the model. This weakness makes it difficult to properly quantify environmental effects which arise in the household (residential) sector, which are better explained by population or the number of households rather than by the level of consumer spending. Forecasts of changes in the distribution of population by region would allow more accurate regional projections of residential environmental impacts. It would also be desirable to incorporate industrial location in the model, so that the regional distribution of industrial pollution could be more accurately forecast. However, the development of models to project changes in the regional distribution of both population and industry would require a major effort, and is probably better approached by a cooperative effort by several ministries.

The structure of the model begins with economic impacts that are translated through the model into environmental impacts. The reverse linkages are totally absent. This a major weakness of the system. It would indeed be desirable to complete the loop by allowing, for example, air emissions to influence the quality and performance of the environmental sink.

The sustainable development framework developed in this study (see, Chapter 2) and elaborated mathematically in Appendix F was not fully implemented in LINK. One major deficiency is that LINK remains a consistency model rather than an optimization model (ie. data limitations regarding resource stocks precluded the estimation of shadow prices and sustainable development paths from the model - linkages H, I, J and K in Table 1). Thus we are unable to calculate shadow prices and sustainable paths. These can only be derived from a dynamic optimization system. At present LINK operates within a comparative static framework but ultimately could be elaborated into a dynamic optimization model.

7.3 Recommendations for future refinements

The limitations defined above form the basis for suggested improvements and extensions. Suggestions and recommendations are described under both data refinements and model extensions.

Data refinements and improvements include:

- improving the reliability and representativeness of the environmental coefficients;
- integrating of the LINK environmental databases with long range transportation of air pollutants and forestry growth and yield models;
- collecting and incorporating stocks of minerals and resources;
- translating county-based economic data into watershed-based data. In other words, completely transforming both the economic and environmental databases into a GIS framework;

- refining and extending the database to include environmental impacts on economic variables; and
- develop and use process based data to describe technology.

Model refinements and improvements include:

- incorporating stock variables into the model such as minerals and forests;
- refine and adopt the extended accounting framework developed within this project;
- extend the static model into a dynamic framework;
- extend the range of environmental variables incorporated into the model, (a good example of which is the incorporation of greenhouse gases and global warming considerations into the model);
- introduce the residential sector into the model and analysis;
- incorporate an optimization routine and choice among processes;
- introduce price responsiveness directly into the body of the model; and
- the calculation of absolute and relative sustainability indicators.

System refinements and improvements include:

- the addition of more environmental screens;
- the incorporation of technology choice;
- a GIS based link to the model;
- printed reports and graphics;
- a better configuration of screens; and
- greater flexibility in the range of inputs and processing of results.

7.4 Potential applications

In its present form, the LINK model offers a wide range of applications. With the extensions and improvements suggested above, LINK could become a basic tool for evaluating economic-environmental impacts.

As demonstrated in Chapter 6, it is possible to define a wide range of usefulness of the model in quantifying economic and environmental trade-offs. The model offers a straightforward and simple quantitative account of the links that tie the economy to the environment. In particular, five applications were demonstrated. This set is by no means restricted to the scenarios presented in Chapter 6. Rather, it is possible to define a much broader perspective on its applicability.

There are three broad areas where LINK can be useful to policy-makers, environmental scientists and economists:

- LINK can be used as a tool to gauge the simple linkages between economic trends or changes on the environment;
- LINK can be used as a tool to quantify trade-offs between different economic activities and paths on the one hand and the environmental impacts that are likely to be associated with the economic change; and
- LINK can be used to measure the sensitivity of the economy and the environment to changes in trends, regulation, incentives, technology and overall economic efficiency.

8.

Conclusions

The LINK model constitutes an important effort to integrate the economy and the natural environment although linkages currently postulated in the model are somewhat rudimentary and unidirectional. The fact that the framework is operational, however, provides a stepping stone from which it is possible to extend and improve.

Substantial effort has been expended on tying the system together and to collect data needed to support it. Even in its present form, the LINK model can be used to identify the consequences of different economic trends on the economy at large and in terms of certain environmental indicators. The present utility of the model was demonstrated in identifying the linkages between the environment and the economy over time under different scenarios about the possible futures of the Ontario economy.

While many questions remain unanswered, they have been clarified and directions for future work have been identified. The focus and the framework is now available to use, to expand and to extend.

References

Ahmad, Y.J., S. El Serafy and E. Lutz. 1989. *Environmental Accounting for Sustainable Development*. New York: The World Bank.

Barnett, H. J. and C. Morse. 1963. *Scarcity and Growth: The Economics of Natural Resource Scarcity*. Baltimore: John Hopkins Press.

Brown L., E.C. Wolf and L. Stance. 1984. *State of the World*. Worldwatch Institute. New York: W.W. Norton & Company.

CH2M Hill Engineering. 1990. *The Physical and Economic Dimensions of Municipal Solid Waste Management in Ontario*. Toronto: Ontario Ministry of the Environment.

Daly, H. and Cobb. J. 1990. *For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future*. Boston: Beacon Press.

Daly, H. 1990. "Towards Some Operational Principles of Sustainable Development", *Ecological Economics* 2(1): 1-6.

Econometric Research Limited (ERL) and VHB Research and Consulting. 1990. *Reuse, Reduce and Recycling: a Theoretical Framework*. Prepared for the National Round Table on the Environment and Economy.

Eckaus R.S. and K.S. Parikh. 1968. *Planning for Growth: Multisectoral, Intertemporal Models Applied to India*. Cambridge, MA: MIT Press.

Georgescu-Roegen, N. 1971. *The Entropy Law and Economic Progress*. Cambridge: Harvard University Press.

Georgescu-Roegen, N. 1976. *Energy and Economic Myths: Institutional and Analytical Economic Essays*. New York: Pergammon Press.

Giarratani, F. J.D. Maddy and C.F. Socher. 1976. *Regional and Interregional Input-Output Analysis: An Annotated Bibliography*. Morgantown: West Virginia University Library.

Gibson, R. 1991. "Should Environmentalists Pursue Sustainable Development?", *Probe Post* 13(4): 22-25.

Government of Canada. 1990. *Canada's Green Plan*. Ottawa: Supply and Services Canada.

Hirsch, F. 1976. *The Social Limits to Growth*. Cambridge: Harvard University Press.

Hoffman, et al. 1976. *Statistics Canada Long Term Simulation Model*. Statistics Canada, Ottawa.

Isard, W.T. and Kuenne. 1990. *Dynamics and Conflict in Regional Structural Change*. Basingstoke: Macmillan.

Isard, W.T. and T.W. Langford. 1971. *Regional Input-Output Study: Recollections, Reflections, and Diverse Notes on the Philadelphia Experience*. Cambridge: MIT Press.

IUCN (International Union for the Conservation of Nature). 1991. *World Conservation Strategy*. Gland, Switzerland: IUCN.

Leontief, W. 1970. Environmental Repercussions and the Economic Structure: An Input-Output Approach. *Review of Economics and Statistics* (August 1970): 262-271.

Meadows D.H. and D.L. Meadows and J. Joergen. 1972. *The Limits to Growth: Conformity, Global Collapse, Envisioning a Sustainable Future*. London: Earth Island Press.

Miernyk, W.H. 1982. *Regional Analysis and Regional Policy*. Cambridge: Oelgeschlager, Gumm and Hain.

Miller, M.H. 1984. *Stresses on Agricultural Land in Ontario*. Ottawa: Science Council of Canada.

National Task Force on Environment and Economy. *Report of the Nation Task Force on Environment and Economy*. Ottawa: Canadian Council of Resource and Environment Ministers.

Ontario NDP Caucus. 1990. *Greening the Party, Greening the Province: A vision for the Ontario NDP*.

Ontario Ministry of the Environment. 1985. *Registration Guidance Manual for Generators of Liquid Industrial and Hazardous Waste*. Toronto: Ontario Ministry of the Environment.

Ontario Ministry of the Environment. 1986. *Municipal-Industrial Strategy for Abatement Strategy (MISA).* Toronto: Ontario Ministry of the Environment.

Ontario Ministry of the Environment. 1987. *Stopping Air Pollution at its Source: CAP Clean Air Program.* Toronto: Ontario Ministry of the Environment.

Ontario Round Table on the Environment and Economy. 1992. *Restructuring for Sustainability.* Toronto: Ontario Round Table on the Economy and the Environment.

Page, Talbot. 1977. *Conservation and Economic Efficiency.* Washington: Resources for the Future.

Pearce, D. and R. Turner. 1990. *Economics of Natural Resources and the Environment.* New York: Harvester Wheatsheaf.

Pezzey, J. 1989. *Economic Analysis of Sustainable Growth and Sustainable Development.* The World Bank Working Paper 15. Environment Department. Washington: The World Bank.

Polanyi, K. 1944. *The Great Transformation.* New York: Farrar and Rinehart.

Polenske, K.R. 1980. *The U.S. Multi-Regional Input-Output Accounts and Model.* Lexington: Lexington Books.

Senes Consultants. 1990. *Estimation of Additional Abatement Costs for the Proposed Revisions to Regulation 308.* Toronto: Ontario Ministry of the Environment.

Shelton, I. J. and G. J. Wall. 1984. *A Proposed Methodology for Mapping Provincial Soil Loss Potential.* Guelph: Ontario Institute of Pedology.

Trant, Douglas F. 1989. *Estimating Agricultural Soil Erosion Losses from Census of Agriculture Crop Coverage Data.* Research Paper 27. Ottawa: Statistics Canada, Analytical Studies Branch.

Trant, D. and H. Trepanier. 1990. *Measuring Environmental Stress on Agricultural Land Using the "Agricultural Practices Impact Model."* Ottawa: Statistics Canada, Environment and Natural Resources Analytical Studies Branch.

VHB Research and Consulting Inc. and CH2M Hill Engineering. 1991. *Water Pollution Abatement Technology and Cost Study.* Toronto: Ontario Ministry of the Environment.

Victor, P. 1972. *Pollution, Economy and Environment.* Toronto: University of Toronto Press.

Victor, P. 1991. Indicators for Sustainable Development: Some Lessons from Capital Theory. In CEAC. 1991. *Economic, Ecological and Decision Theories.* Ottawa: Canadian Environmental Advisory Council.

Vitousek et al. 1986. Human Appropriation of the Products of Photosynthesis. *Bioscience* 34(6): 368-373.

Viner, Jacob. 1965. Guide to John Rae's Life of Adam Smith. Introduction to: *Life of Adam Smith* by J. Rae. New York: A.M. Kelley.

Woods Gordon. 1989. *Ontario's Environmental Protection Industry*. Toronto: Ontario Ministry of the Environment.

World Commission on Environment and Development (The Brundtland Commission). 1987. *Our Common Future*. Oxford: Oxford University Press.

Table 8,... Estimates of costs and percent reductions by sector based on the maximum technically achievable level of abatement

Sector Capital cost ($M) Operating cost ($M) Number of
plants Conventional
contaminants Non-Conventional
contaminants
Metal contaminants
REIM number

Ammonia-N
(t/a) Oil and
grease
(t/a) Total
phosphorus
(t/a) TSS
(t/a) Total
cyanide
(t/a) Phenolics
(4AAP)
(t/a) Copper
(t/a) Lead
(t/a) Zinc
(t/a)
Pulp and paper $1 351.0 $63.3 27 335.0
10
Initial loading b. ND 264.0 3 6 4 0 0 0
ND ND ND ND 52.1
Final loading b. ND 153.0 4 970.0 ND ND
ND ND 0
% reduction 8% 0% 42% 86% 0% 0%
0% 0% 0%
Iron and steel $345.5 $48.2 4
12
Initial loading 863.4 549.5 ND 4 175.9 88.7 17.0
ND 6.0 29.0
Final loading 95.7 57.05 ND 240.6 15.2 0.3
ND 0.3 1.4
% reduction 89% 90% ND 94% 83% 98%
ND 96% 95%
Metal mining $172.2 $15.5 30
4
Initial loading 658.5 277.9 ND 1 784.4 33.8 2.3 83
3.0 30.6
Final loading 658.5 277.9 ND 1 238.0 25.2 2.3 20
2.9 5.1
% reduction 0% 0% ND 31% 25% 0%
72% 4% 83%
Industrial minerals $78.7 $211.7 20
17
Initial loading ND 122.6 1.0 1 704.8 ND ND
ND ND ND
Final loading ND 122.6 1.0 317.4 ND ND
ND ND ND
% reduction 30% 0% 0% 81% ND ND
ND ND ND
Metal casting $64.9 $4.7 3
13
Initial loading a. ND 0.1 1 172.3 0.7 8.8
ND ND 45.7
Final loading a. ND 0.0 3.1 0.0 0.0
ND ND 0.1
% reduction 98% ND 0% 100% 97% 100%
0% 0% 100%
Petroleum refining $96.4 $13.3 6
18
Initial loading 30.2 57.6 1.2 565.6 ND 0.2
ND 0.6 4 4

Final loading 20.3 48.3 0.0 278.9 ND 0.1

ND 0.0 0.5

% reduction 33% 16% 0% 51% ND 32%

ND 0% 89%

Organic chemical $637.3 $85.0 20

-

Initial loading 88.2 190.7 23.6 1 539.6 1.2 0.7 22

10.2 2.3

Final loading 26.2 152.8 15.7 607.8 1.2 0.3 61

1.7 1.4

% reduction 70% 20% 33% 61% 0% 63%

27% 84% 41%

Inorganic chemical $51.2 $8.1 11

-

Initial loading 372.6 163.7 46.4 3 043.3 1.2 0.8 61

4.0 3.2

Final loading 60.3 137.1 44.6 2 332.2 1.1 0.7 51

3.7 3.0

% reduction 84% 16% 4% 23% 15% 7%

9% 7% 6%

Total chemical products $688.5 $93.1 31

19

Initial loading 460.8 354.4 70.0 4 582.9 2.4 1.5 83

14.2 5.5

Final loading 86.5 289.9 60.3 2 940.0 2.3 1.0 13

5.4 4.4

% reduction 81% 18% 14% 36% 8% 33%

19% 62% 20%

Electric Power $5 365.7 $908.3 14

16

Initial loading ND ND ND 4 281.7 ND ND 75

ND 3.4

Final loading ND ND ND 9.8 ND ND 70

ND 0.8

% reduction ND ND ND 100% ND ND

87% ND 77%

NOTES: ND - Not detected or below the detection limit.

a - Percentage reduction based on nitrate + nitrite (derivative of Ammonia-N).

b - Percentage reduction based on TKN (derivative of Ammonia-N).

Appendix A.

LINK Model users manual

Ontario Economy / Environment Link Model

User's Guide

October, 1992

Econometric Research Ltd

Table of Contents

Installing the Program 1

Running The Program 1

Input Options 2

Output Options 7

- Economic Impacts 7
- Environmental Impacts 9

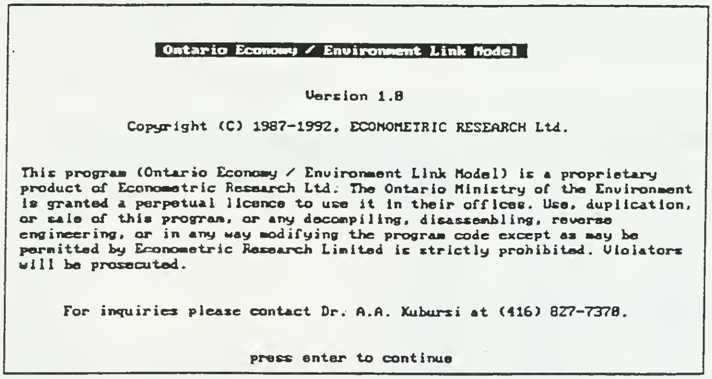
Installing the Program

The distribution diskette contains all of the files which are needed to run LINK. You must first copy all of the files to a directory on your hard disk, for example C:\LINK, in order to use the program. Link will run from the diskette, but the reading of the data files will take much longer.

Once you have created the directory (MD \LINK) you should make the new directory the current directory (CD \LINK). You can then copy all of the files from the distribution diskette to the hard disk (COPY A:*.*).

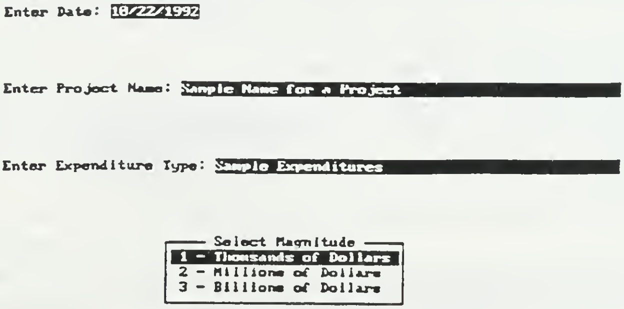
Running the Program

Once the program is installed, make sure that the current directory is the one into which the LINK files were copied, and initiate program execution by typing LINK at the DOS prompt. You will then see the opening title screen as shown below:



```
                Ontario Economy / Environment Link Model

                              Version 1.0

             Copyright (C) 1987-1992, ECONOMETRIC RESEARCH Ltd.

This program (Ontario Economy / Environment Link Model) is a proprietary
product of Econometric Research Ltd. The Ontario Ministry of the Environment
is granted a perpetual licence to use it in their offices. Use, duplication,
or sale of this program, or any decompiling, disassembling, reverse
engineering, or in any way modifying the program code except as may be
permitted by Econometric Research Limited is strictly prohibited. Violators
will be prosecuted.

      For inquiries please contact Dr. A.A. Kubursi at (416) 827-7370.

                         press enter to continue
```

To continue with program execution, you need only press the Enter key. You will then be shown the main menu as shown below.



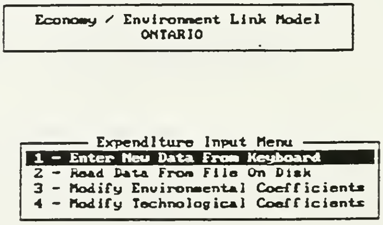
```
Enter Date: 10/22/1992


Enter Project Name: Sample Name for a Project


Enter Expenditure Type: Sample Expenditures


                     ─── Select Magnitude ───
                     1 - Thousands of Dollars
                     2 - Millions of Dollars
                     3 - Billions of Dollars
```

On this screen you are asked for several pieces of information one at a time. The first item you ar asked for is the date. The current system date of the computer is the default date, and you can accept i by simply pressing Enter. You can, however, type in a new data if you desire.

Once you have pressed enter on the date field, you are asked for the name of the project you wish to analyze, as well as a name for the type expenditure. You can type in any descriptive text in these tw input fields. The text you type in will appear on several of the output screens, and will be printed along with the rest of the information on the screen if you ask for the screen to be printed.

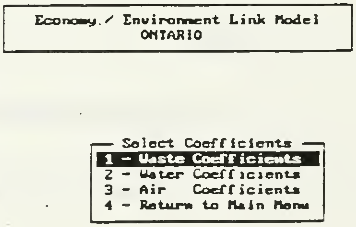
The last item on this screen is a menu from which you should select the magnitude of the values you wish to use for the duration of the program. You can select to work in thousands of dollars (the default), millions of dollars or billions of dollars. This menu is similar in structure to many of the menus that appear in the program. You can use the up and down arrows to move the menu bar, and press the enter key to select the item the menu bar is currently on.

Once this screen has been completed, the main menu appears as shown below:

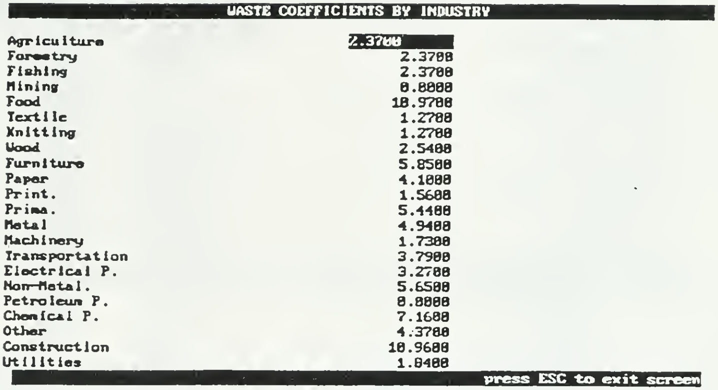

Economy / Environment Link Model
ONTARIO
Expenditure Input Menu
1 - Enter New Data From Keyboard
2 - Read Data From File On Disk
3 - Modify Environmental Coefficients
4 - Modify Technological Coefficients

Input Options

By selecting option 1, you can proceed with the program, however you may wish to modify the Environmental and Technological coefficients used in the program. You can do this by selection option 3 or option 4 respectively. If you select option 3, the following Select Coefficients menu will appear:

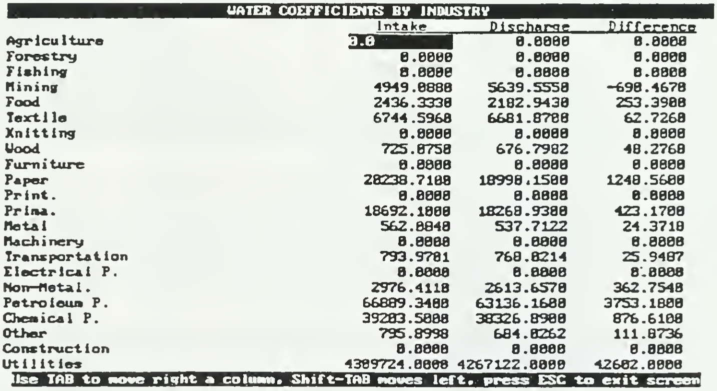


By selecting options 1, 2 or 3, you can modify the respective coefficients used by the system. In order to modify the waste coefficients, chose option 1 and the input screen shown on the next page will appear.



```
                    WASTE COEFFICIENTS BY INDUSTRY

Agriculture                              2.3700
Forestry                                 2.3700
Fishing                                  2.3700
Mining                                   0.0000
Food                                    10.9700
Textile                                  1.2700
Knitting                                 1.2700
Wood                                     2.5400
Furniture                                5.8500
Paper                                    4.1000
Print.                                   1.5600
Prima.                                   5.4400
Metal                                    4.9400
Machinery                                1.7300
Transportation                           3.7900
Electrical P.                            3.2700
Non-Metal.                               5.6500
Petroleum P.                             0.0000
Chemical P.                              7.1600
Other                                    4.3700
Construction                            10.9600
Utilities                                1.8400
                                              press ESC to exit screen
```

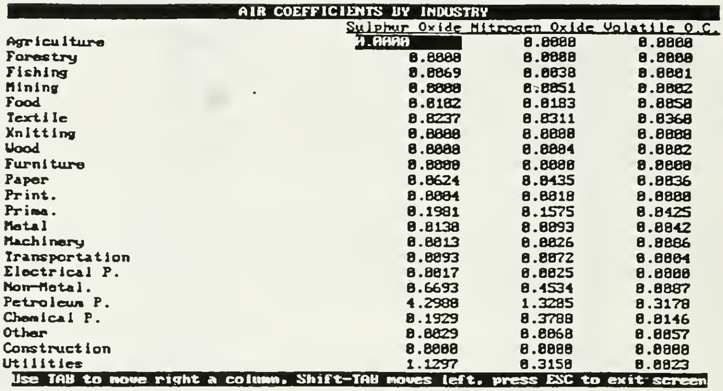
You can enter new values for the highlighted quantity. Use the up and down arrows to change which quantity is highlighted. The screen scrolls to display mor industries as you continue to press the down arrow. Press ESC to exit the screen. The Select Coefficients menu will appear again, and you could choose option 2 to see the following screen which allows you to modify the water coefficients in much the same manner as you modified the waste coefficients:



```
                    WATER COEFFICIENTS BY INDUSTRY
                                    Intake        Discharge     Difference
Agriculture                    0.0                   0.0000         0.0000
Forestry                             0.0000          0.0000         0.0000
Fishing                              0.0000          0.0000         0.0000
Mining                            4949.0880       5639.5550      -690.4670
Food                              2436.3330       2182.9430       253.3900
Textile                           6744.5960       6681.8700        62.7260
Knitting                             0.0000          0.0000         0.0000
Wood                               725.0750        676.7982        48.2768
Furniture                            0.0000          0.0000         0.0000
Paper                            28238.7100      18998.1500      1240.5600
Print.                               0.0000          0.0000         0.0000
Prima.                           18692.1000      18268.9300       423.1700
Metal                              562.0840        537.7122        24.3718
Machinery                            0.0000          0.0000         0.0000
Transportation                     793.9701        768.0214        25.9487
Electrical P.                        0.0000          0.0000         0.0000
Non-Metal.                        2976.4110       2613.6570       362.7540
Petroleum P.                     66889.3400      63136.1600      3753.1800
Chemical P.                      39203.5000      38326.8900       876.6100
Other                              795.8998        684.0262       111.8736
Construction                         0.0000          0.0000         0.0000
Utilities                      4309724.0000    4267122.0000     42602.0000
 Use TAB to move right a column, Shift-TAB moves left, press ESC to exit screen
```

On this screen, there is more than one column, and you can move between columns using the TAB key to move to the next column to the right, or use Shift-TAB to move one column to the left. Note that on this screen, the third column is a calculated column that you cannot directly modify. Press ESC when you are happy with the coefficients.

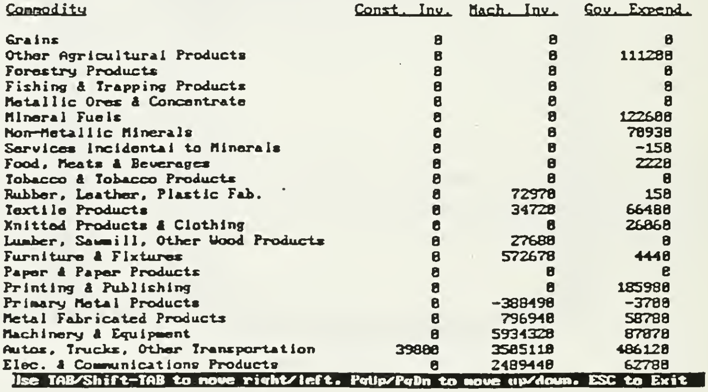
Similarly, by selecting option 3 from the Select Coefficients menu, you can modify the air coefficients on the input screen shown on the top of the next page.



```
                          AIR COEFFICIENTS BY INDUSTRY
                                    Sulphur Oxide Nitrogen Oxide Volatile O.C.
Agriculture                          0.0000          0.0000        0.0000
Forestry                             0.0000          0.0000        0.0000
Fishing                              0.0069          0.0030        0.0001
Mining                               0.0000          0.0051        0.0002
Food                                 0.0102          0.0103        0.0050
Textile                              0.0237          0.0311        0.0360
Knitting                             0.0000          0.0000        0.0000
Wood                                 0.0000          0.0004        0.0002
Furniture                            0.0000          0.0000        0.0000
Paper                                0.0624          0.0435        0.0036
Print.                               0.0004          0.0010        0.0000
Prima.                               0.1901          0.1575        0.0425
Metal                                0.0130          0.0093        0.0042
Machinery                            0.0013          0.0026        0.0006
Transportation                       0.0093          0.0072        0.0004
Electrical P.                        0.0017          0.0025        0.0000
Non-Metal.                           0.6693          0.4534        0.0007
Petroleum P.                         4.2900          1.3205        0.3170
Chemical P.                          0.1929          0.3700        0.0146
Other                                0.0029          0.0060        0.0057
Construction                         0.0000          0.0000        0.0000
Utilities                            1.1297          0.3150        0.0023
 Use TAB to move right a column, Shift-TAB moves left, press ESC to exit screen
```

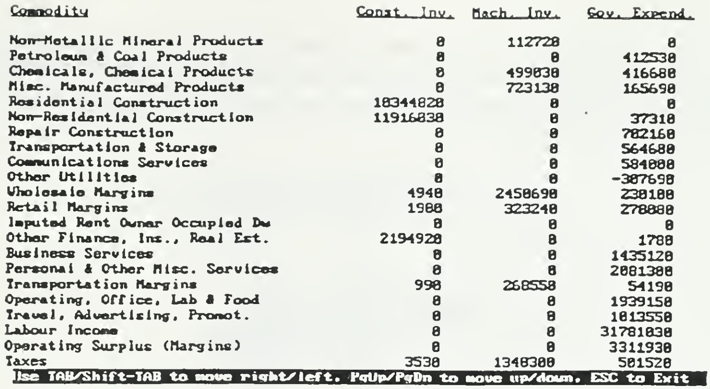
Once you are satisfied with the coefficients, press ESC to return to the Select Coefficients menu, then press ESC again to return to the main menu.

You can now proceed to select option 1. (Note that you do not need to select option 3 or 4 from the main menu unless you want to change the default coefficients.) After you select option 1, you are presented with the following screen of values to view.

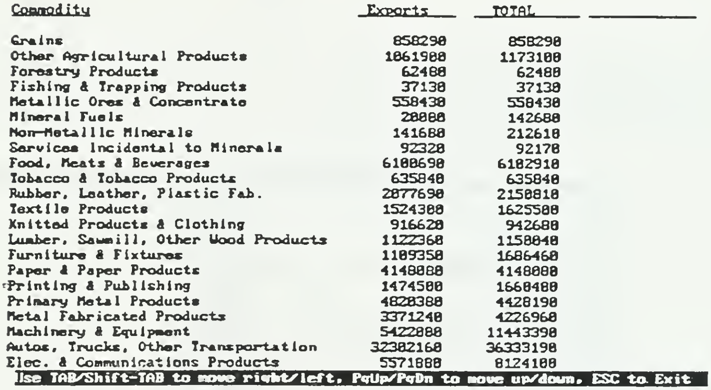


```
Commodity                                Const. Inv.  Mach. Inv.   Gov. Expend.

Grains                                             0           0              0
Other Agricultural Products                        0           0         111200
Forestry Products                                  0           0              0
Fishing & Trapping Products                        0           0              0
Metallic Ores & Concentrate                        0           0              0
Mineral Fuels                                      0           0         122600
Non-Metallic Minerals                              0           0          70930
Services Incidental to Minerals                    0           0           -150
Food, Meats & Beverages                            0           0           2220
Tobacco & Tobacco Products                         0           0              0
Rubber, Leather, Plastic Fab.                      0       72970            150
Textile Products                                   0       34720          66400
Knitted Products & Clothing                        0           0          26060
Lumber, Sawmill, Other Wood Products               0       27600              0
Furniture & Fixtures                               0      572670           4440
Paper & Paper Products                             0           0              0
Printing & Publishing                              0           0         185900
Primary Metal Products                             0     -300490          -3700
Metal Fabricated Products                          0      796940          50700
Machinery & Equipment                              0     5934320          87070
Autos, Trucks, Other Transportation            39000     3505110         406120
Elec. & Communications Products                    0     2409440          62700
 Use TAB/Shift-TAB to move right/left. PgUp/PgDn to move up/down. ESC to Exit
```

There are more values than can fit on one page, but you can use the TAB and Shift-TAB keys to see different columns and the PgDn and PgUp keys to see more commodities. The following two screens show two of the other screens that you can see by pressing TAB and PgDn.

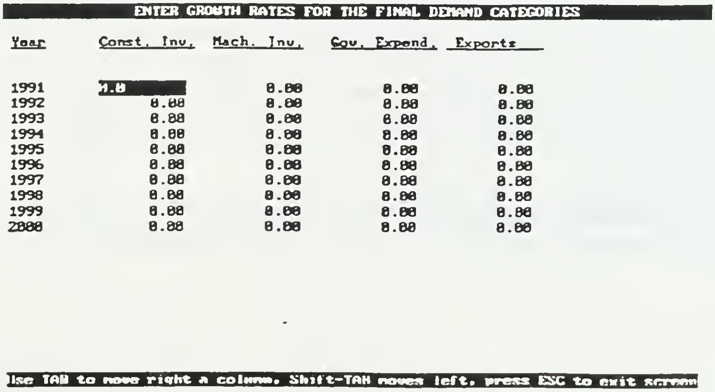


```
Commodity                           Const. Inv.  Mach. Inv.   Gov. Expend.

Non-Metallic Mineral Products                 0      112720              0
Petroleum & Coal Products                     0           0         412530
Chemicals, Chemical Products                  0      499030         416680
Misc. Manufactured Products                   0      723130         165690
Residential Construction               18344820           0              0
Non-Residential Construction           11916830           0          37310
Repair Construction                           0           0         782160
Transportation & Storage                      0           0         564680
Communications Services                       0           0         584000
Other Utilities                               0           0        -307690
Wholesale Margins                          4940     2450690         230100
Retail Margins                             1900      323240         278000
Imputed Rent Owner Occupied Dw                0           0              0
Other Finance, Ins., Real Est.          2194920           0           1700
Business Services                             0           0        1435120
Personal & Other Misc. Services               0           0        2081300
Transportation Margins                      990      268550          54190
Operating, Office, Lab & Food                 0           0        1939150
Travel, Advertising, Promot.                  0           0        1013550
Labour Income                                 0           0       31781030
Operating Surplus (Margins)                   0           0        3311930
Taxes                                      3530     1340300         501520
 Ise TAB/Shift-TAB to move right/left. PgUp/PgDn to move up/down. ESC to Exit
```



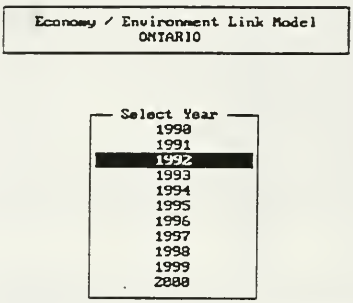
```
Commodity                              Exports       TOTAL

Grains                                  858290      858290
Other Agricultural Products            1061900     1173100
Forestry Products                        62400       62400
Fishing & Trapping Products              37130       37130
Metallic Ores & Concentrate             558430      558430
Mineral Fuels                            20000      142680
Non-Metallic Minerals                   141680      212610
Services Incidental to Minerals          92320       92170
Food, Meats & Beverages                6100690     6102910
Tobacco & Tobacco Products              635840      635840
Rubber, Leather, Plastic Fab.          2077690     2150810
Textile Products                       1524300     1625500
Knitted Products & Clothing             916620      942680
Lumber, Sawmill, Other Wood Products   1122360     1150840
Furniture & Fixtures                   1109350     1686460
Paper & Paper Products                 4140000     4140000
Printing & Publishing                  1474500     1660400
Primary Metal Products                 4820380     4428190
Metal Fabricated Products              3371240     4226960
Machinery & Equipment                  5422000    11443390
Autos, Trucks, Other Transportation   32302160    36333190
Elec. & Communications Products        5571000     8124100
 Ise TAB/Shift-TAB to move right/left. PgUp/PgDn to move up/down. ESC to Exit
```

You can press ESC to proceed to the growth rate input screen shown below. On this screen, you enter the expected growth rates for the specified investment/expenditure categories for each year. Enter the values in percentages. For example, if you expect that investment in construction will increase by 5 percent in 1991, then enter 5.0 in the upper left field. Use the arrows and TAB to move, press ESC when done.



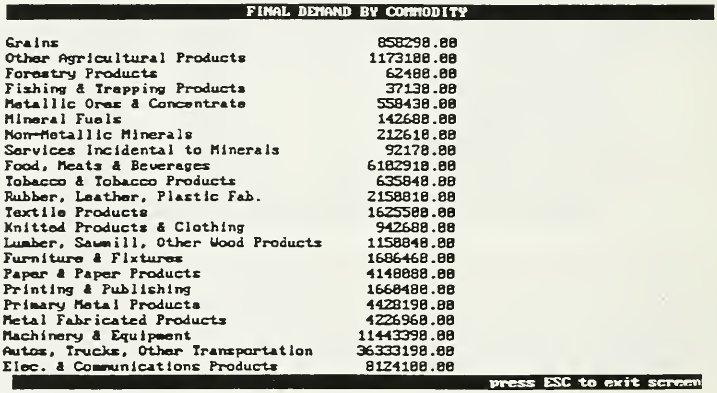
```
             ENTER GROWTH RATES FOR THE FINAL DEMAND CATEGORIES

Year      Const. Inv.  Mach. Inv.   Gov. Expend.  Exports


1991      5.0                0.00          0.00         0.00
1992             0.00        0.00          0.00         0.00
1993             0.00        0.00          0.00         0.00
1994             0.00        0.00          0.00         0.00
1995             0.00        0.00          0.00         0.00
1996             0.00        0.00          0.00         0.00
1997             0.00        0.00          0.00         0.00
1998             0.00        0.00          0.00         0.00
1999             0.00        0.00          0.00         0.00
2000             0.00        0.00          0.00         0.00





Ise TAB to move right a column. Shift-TAB moves left. press ESC to exit screen
```

Once you have entered the growth rates, you are asked to select a year for which you wish to perform an analysis. It only makes sense to choose a year as far in the future as you have provided growth rates, unless you are studying a zero growth scenario. Select a year using the up and down arrows, then press enter.



```
Economy / Environment Link Model
            ONTARIO

   Select Year
      1990
      1991
      1992
      1993
      1994
      1995
      1996
      1997
      1998
      1999
      2000
```

Once you select a year, the final demand vector for that year is calculated using the input growth rates, and is displayed for you on the following screen.



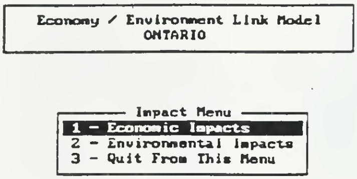
```
                         FINAL DEMAND BY COMMODITY

Grains                                       858290.00
Other Agricultural Products                 1173100.00
Forestry Products                             62400.00
Fishing & Trapping Products                   37130.00
Metallic Ores & Concentrate                  558430.00
Mineral Fuels                                142600.00
Non-Metallic Minerals                        212610.00
Services Incidental to Minerals               92170.00
Food, Meats & Beverages                     6182910.00
Tobacco & Tobacco Products                   635840.00
Rubber, Leather, Plastic Fab.               2158810.00
Textile Products                            1625500.00
Knitted Products & Clothing                  942600.00
Lumber, Sawmill, Other Wood Products        1158840.00
Furniture & Fixtures                        1686460.00
Paper & Paper Products                      4140000.00
Printing & Publishing                       1660400.00
Primary Metal Products                      4428190.00
Metal Fabricated Products                   4226960.00
Machinery & Equipment                      11443390.00
Autos, Trucks, Other Transportation        36333190.00
Elec. & Communications Products             8124100.00
                                                      press ESC to exit scree
```

You can use the PgDn and PgUp keys to see the values for all of the commodities. Once you have finished viewing the demand vector, press ESC to proceed to the calculation stage. As each stage of the calculation progresses, you will see a small window appear informing you of the progress. On faster machines equipped with numeric coprocessors, these windows will flash by too quickly to read, but don't worry about it.

Once the calculation stages are complete, the program allows you to view the outputs in a variety of different output screens. These are the topic of the next section.

Output Options

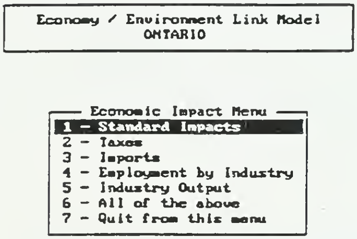
Once the calculations are complete, you are presented with the following menu:



```
            Economy / Environment Link Model
                        ONTARIO


                  ---- Impact Menu ----
                 1 - Economic Impacts
                 2 - Environmental Impacts
                 3 - Quit From This Menu
```

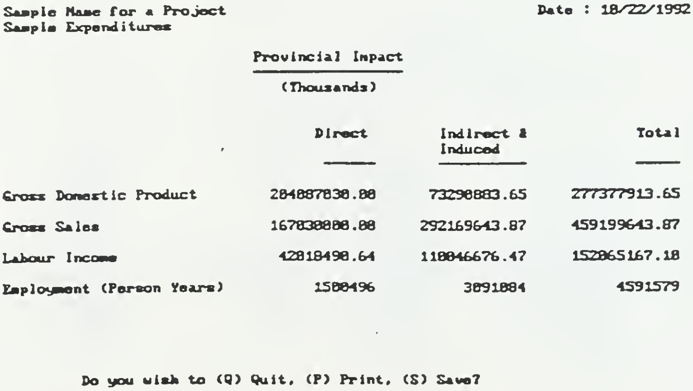
Economic Impacts

By selecting option 1, you can view the economic impacts. The following menu of economic impacts is presented:

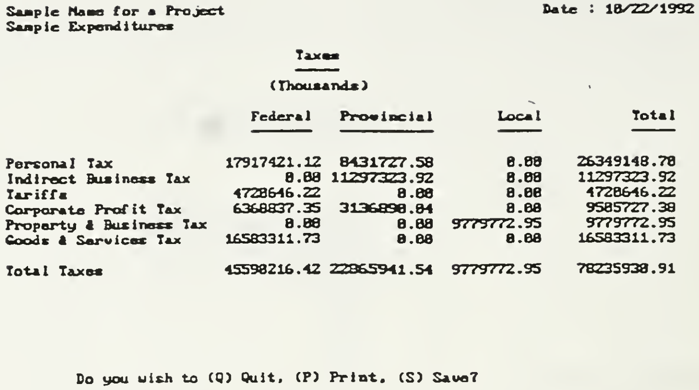


```
            Economy / Environment Link Model
                        ONTARIO


               ---- Economic Impact Menu ----
               1 - Standard Impacts
               2 - Taxes
               3 - Imports
               4 - Employment by Industry
               5 - Industry Output
               6 - All of the above
               7 - Quit from this menu
```

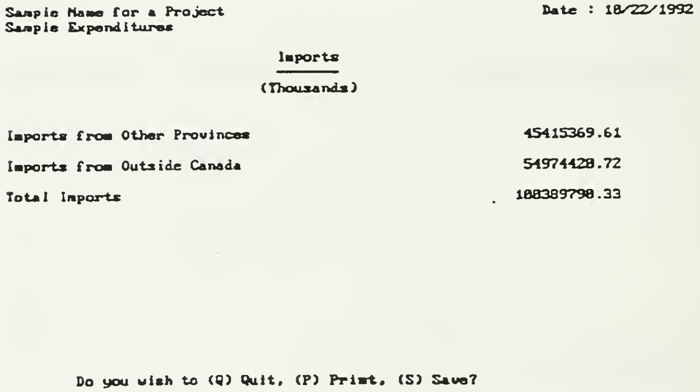
The following five screens show samples of each of the economic impact output screens obtained by selecting each of the first 5 items of the menu in order.



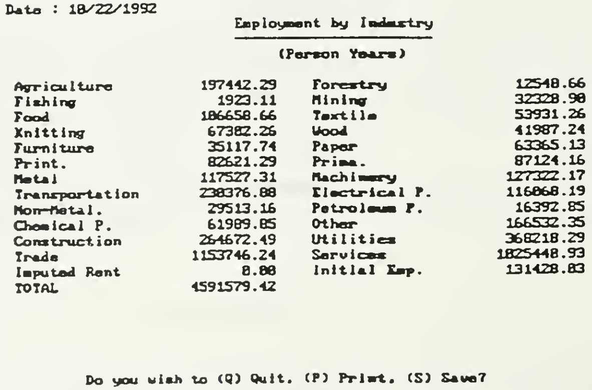
```
Sample Name for a Project                                    Date : 10/22/1992
Sample Expenditures

                         Provincial Impact
                         -----------------
                            (Thousands)

                                Direct      Indirect &           Total
                                            Induced
                                ------      ----------           -----

Gross Domestic Product    204087030.00     73290883.65    277377913.65

Gross Sales               167030000.00    292169643.87    459199643.87

Labour Income              42018490.64    110846676.47    152865167.10

Employment (Person Years)      1500496         3091084         4591579



              Do you wish to (Q) Quit, (P) Print, (S) Save?
```



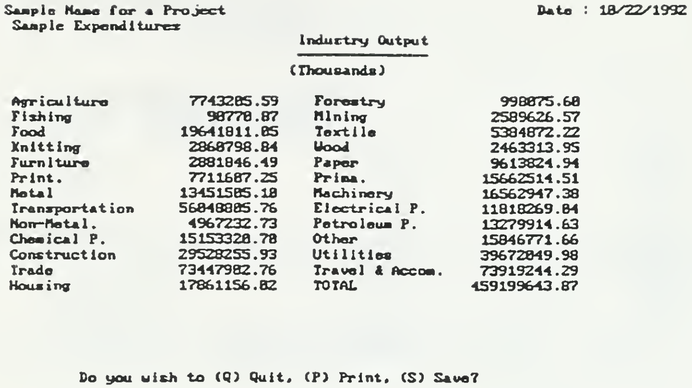
```
Sample Name for a Project                                   Date : 10/22/1992
Sample Expenditures

                                   Taxes

                                (Thousands)

                             Federal     Provincial        Local          Total

Personal Tax              17917421.12   8431727.58          0.00    26349148.70
Indirect Business Tax            0.00  11297323.92          0.00    11297323.92
Tariffs                    4728646.22         0.00          0.00     4728646.22
Corporate Profit Tax       6368837.35   3136890.04          0.00     9505727.38
Property & Business Tax          0.00         0.00    9779772.95     9779772.95
Goods & Services Tax      16583311.73         0.00          0.00    16583311.73

Total Taxes               45598216.42  22865941.54    9779772.95    78235930.91



         Do you wish to (Q) Quit, (P) Print, (S) Save?
```



```
Sample Name for a Project                                   Date : 10/22/1992
Sample Expenditures

                                  Imports

                                (Thousands)

Imports from Other Provinces                                45415369.61

Imports from Outside Canada                                 54974420.72

Total Imports                                              100389790.33



         Do you wish to (Q) Quit, (P) Print, (S) Save?
```



```
Date : 10/22/1992
                          Employment by Industry

                              (Person Years)

Agriculture            197442.29    Forestry                12548.66
Fishing                  1923.11    Mining                  32328.98
Food                   186658.66    Textile                 53931.26
Knitting                67382.26    Wood                    41987.24
Furniture               35117.74    Paper                   63365.13
Print.                  82621.29    Prima.                  87124.16
Metal                  117527.31    Machinery              127322.17
Transportation         238376.88    Electrical P.          116868.19
Non-Metal.              29513.16    Petroleum P.            16392.85
Chemical P.             61989.85    Other                  166532.35
Construction           264672.49    Utilities              368218.29
Trade                 1153746.24    Services              1825448.93
Imputed Rent                0.00    Initial Exp.           131428.83
TOTAL                 4591579.42



         Do you wish to (Q) Quit, (P) Print, (S) Save?
```



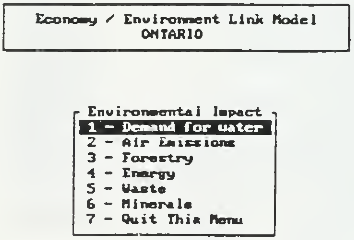
```
Sample Name for a Project                                   Date : 18/22/1992
 Sample Expenditures
                                     Industry Output
                                     ---------------
                                       (Thousands)

 Agriculture          7743285.59   Forestry               998875.68
 Fishing                98778.87   Mining                2589626.57
 Food                19641811.85   Textile               5384872.22
 Knitting             2868798.84   Wood                  2463313.95
 Furniture            2881846.49   Paper                 9613824.94
 Print.               7711687.25   Prima.               15662514.51
 Metal               13451585.18   Machinery            16562947.38
 Transportation      56848885.76   Electrical P.        11818269.84
 Non-Metal.           4967232.73   Petroleum P.         13279914.63
 Chemical P.         15153328.78   Other                15846771.66
 Construction        29528255.93   Utilities            39672849.98
 Trade               73447982.76   Travel & Accom.      73919244.29
 Housing             17861156.82   TOTAL               459199643.87


              Do you wish to (Q) Quit, (P) Print, (S) Save?
```

At the bottom of each of these 5 screens there is the message that you have the option to Quit, Print or Save the screen. If you press P, the screen will automatically print on you printer and the page will be ejected. If you press S, the screen will be written to a file for you. Each of the screens has a specific extension for the filename. If you press Q, you will be returned to the Economic Impacts menu.

To exit from the Economic Impacts menu, press ESC. The Impact menu will then re-appear, allowing you to select option 2 in order to view the Environmental Impact menu shown in the next section.

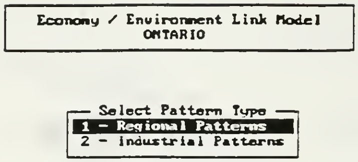
Environmental Impacts

By selecting option 2 from the Impacts Menu, you will be presented with the following Environmental Impacts menu.



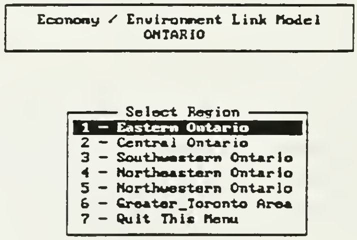
```
Economy / Environment Link Model
            ONTARIO

   Environmental Impact
   1 - Demand for water
   2 - Air Emissions
   3 - Forestry
   4 - Energy
   5 - Waste
   6 - Minerals
   7 - Quit This Menu
```

For each of the options on this menu, there is a sub-menu which appears which asks whether you wish to view regional patterns or industrial patterns. The screen at the top of the next page shows a sample of this menu.



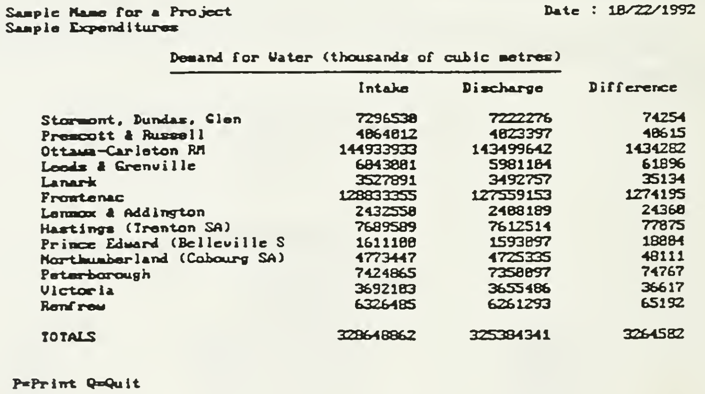
```
Economy / Environment Link Model
            ONTARIO

     Select Pattern Type
   1 - Regional Patterns
   2 - Industrial Patterns
```

If you select regional patters from this menu, then the following menu of regions appears allowing you to specify where you would like to see the effect of the project.

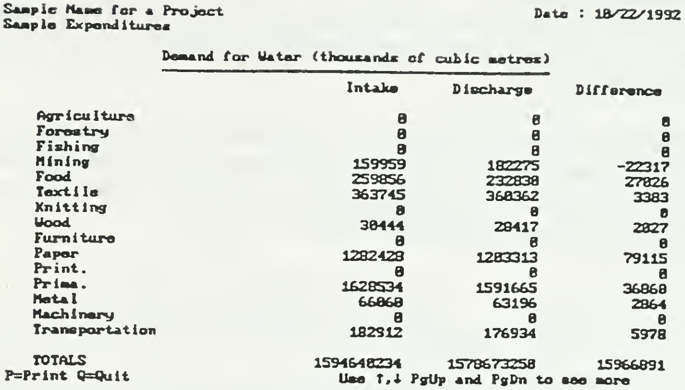


```
Economy / Environment Link Model
            ONTARIO

        Select Region
   1 - Eastern Ontario
   2 - Central Ontario
   3 - Southwestern Ontario
   4 - Northeastern Ontario
   5 - Northwestern Ontario
   6 - Greater_Toronto Area
   7 - Quit This Menu
```

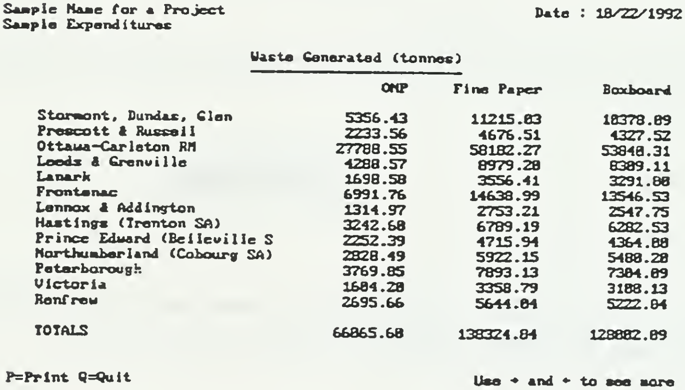
The following screens show samples of each of the output screens selected in order from the Environmental Impacts menu for both regional and industrial patters.



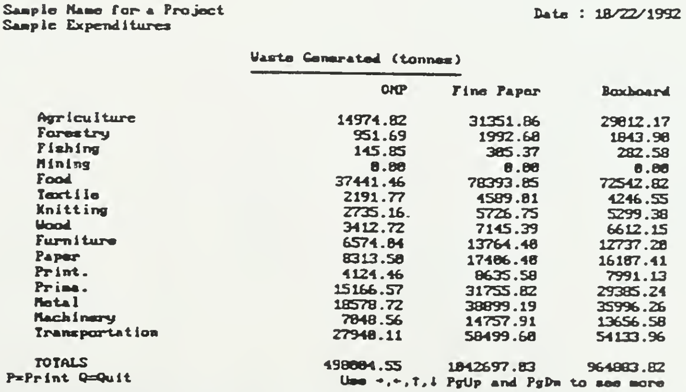
```
Sample Name for a Project                                  Date : 10/22/1992
Sample Expenditures

                     Demand for Water (thousands of cubic metres)

                                       Intake      Discharge     Difference

   Stormont, Dundas, Glen             7296530        7222276          74254
   Prescott & Russell                 4064012        4023397          40615
   Ottawa-Carleton RM               144933933      143499642        1434282
   Leeds & Grenville                  6043081        5981184          61896
   Lanark                             3527891        3492757          35134
   Frontenac                        128833355      127559153        1274195
   Lennox & Addington                 2432550        2408189          24360
   Hastings (Trenton SA)              7689589        7612514          77075
   Prince Edward (Belleville S        1611100        1593097          18004
   Northumberland (Cobourg SA)        4773447        4725335          48111
   Peterborough                       7424865        7350097          74767
   Victoria                           3692103        3655486          36617
   Renfrew                            6326485        6261293          65192

   TOTALS                           328648862      325384341        3264582

P=Print Q=Quit
```



```
Sample Name for a Project                                      Date : 10/22/1992
Sample Expenditures

                    Demand for Water (thousands of cubic metres)
                    ____________________________________________
                                       Intake      Discharge      Difference

  Agriculture                               0              0               0
  Forestry                                  0              0               0
  Fishing                                   0              0               0
  Mining                               159959         182275          -22317
  Food                                 259856         232830           27026
  Textile                              363745         360362            3383
  Knitting                                  0              0               0
  Wood                                  30444          28417            2027
  Furniture                                 0              0               0
  Paper                               1282428        1203313           79115
  Print.                                    0              0               0
  Prima.                              1628534        1591665           36868
  Metal                                 66060          63196            2864
  Machinery                                 0              0               0
  Transportation                       182912         176934            5978

  TOTALS                           1594640234     1578673258        15966891
P=Print Q=Quit                        Use ↑,↓ PgUp and PgDn to see more
```



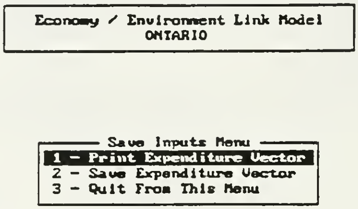
```
Sample Name for a Project                                      Date : 10/22/1992
Sample Expenditures

                          Waste Generated (tonnes)
                          ________________________
                                         OMP      Fine Paper        Boxboard

  Stormont, Dundas, Glen             5356.43        11215.03        10378.09
  Prescott & Russell                 2233.56         4676.51         4327.52
  Ottawa-Carleton RM                27788.55        58182.27        53840.31
  Leeds & Grenville                  4288.57         8979.20         8309.11
  Lanark                             1698.58         3556.41         3291.00
  Frontenac                          6991.76        14638.99        13546.53
  Lennox & Addington                 1314.97         2753.21         2547.75
  Hastings (Trenton SA)              3242.60         6789.19         6282.53
  Prince Edward (Belleville S        2252.39         4715.94         4364.00
  Northumberland (Cobourg SA)        2828.49         5922.15         5480.20
  Peterborough                       3769.85         7893.13         7304.09
  Victoria                           1604.20         3358.79         3108.13
  Renfrew                            2695.66         5644.04         5222.84

  TOTALS                            66065.60       138324.84       128002.09

P=Print Q=Quit                                  Use → and ← to see more
```



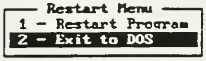
```
Sample Name for a Project                                      Date : 10/22/1992
Sample Expenditures

                          Waste Generated (tonnes)
                          ________________________
                                         OMP      Fine Paper        Boxboard

  Agriculture                       14974.02        31351.86        29012.17
  Forestry                            951.69         1992.60         1843.90
  Fishing                             145.85          305.37          282.58
  Mining                                0.00            0.00            0.00
  Food                              37441.46        78393.85        72542.82
  Textile                            2191.77         4589.01         4246.55
  Knitting                           2735.16.        5726.75         5299.38
  Wood                               3412.72         7145.39         6612.15
  Furniture                          6574.04        13764.40        12737.20
  Paper                              8313.50        17406.40        16107.41
  Print.                             4124.46         8635.58         7991.13
  Prima.                            15166.57        31755.82        29385.24
  Metal                             18578.72        38899.19        35996.26
  Machinery                          7048.56        14757.91        13656.58
  Transportation                    27940.11        58499.60        54133.96

  TOTALS                           498004.55      1042697.83       964883.82
P=Print Q=Quit                  Use →,←,↑,↓ PgUp and PgDn to see more
```

On each screen, there is a set of special keys described on the bottom line of the screen. Some screens have more keys than others, as not all screens can scroll up and down or left and right to see more data (some do both). On each screen, there is the chance to print the screen by pressing P, or you can exit the screen by pressing Q.

Once you have viewed all of the output screens and have pressed ESC to exit from the Impacts menu, you will be presented with the following list of choices regarding the calculated demand vector. You can print it by selecting option 1, or you can save it to a file which can then be read back in via option 2 of the main menu when you run the program again.


Economy / Environment Link Model
ONTARIO
Save Inputs Menu
1 - Print Expenditure Vector
2 - Save Expenditure Vector
3 - Quit From This Menu

Once you have quit from the above menu, the following menu will appear:



From this menu, you can select to run the program again without having to exit to DOS, or you can choose to quit the program completely and return to the DOS prompt.

Appendix B.

Detailed description of environmental database

This appendix provides detailed information regarding the environmental databases used in the LINK model.

A data summary sheet is included for each data category. For each category, the database structure describes the following:

- data source and contact name;
- structure of the records and fields in the database;
- geographic information available in the database;
- data processing and manipulation for geographical referencing;
- uncertainty and limitations associated with the data; and
- potential refinements to database.

Databases for the following resource and environmental categories are included:

- agricultural production
- air emissions
- wood fibre production
- hazardous waste generation
- mineral production and deposits
- municipal sewage generation
- industrial water consumption

B.1 Data summary sheet — agriculture production

SOURCE(S)

Ministry of Agriculture and Food. 1990. *Agricultural Statistics for Ontario.* Toronto: Statistical Services Unit, Economics and Policy Coordination Branch, Ontario Ministry of Agriculture and Food.

CONTACT

Not available.

DATA FORMAT

Electronic spreadsheet format. Fields included:

- County
- Year
- Area-acres
- Area-hectares
- Region
- Crop
- Production in thousands of tonnes
- Total value in thousands of dollars

GEOGRAPHICAL INFORMATION

Information is provided by county.

DATA PROCESSING

To reallocate production from counties to watersheds, county and watershed polygons were overlaid in the GIS. The ratio of the watershed in the county to the total area of the county was used to equally prorate the annual production of each crop in the county. The watershed total was calculated by aggregating the individual county proportions. The implicit assumption in this method is that production occurred uniformly throughout the county. In Northern Ontario this assumption was less valid since the areas of the counties are extremely large, with many contained or partially contained sub-sub watersheds and with much greater variability in agricultural production. Consequently agricultural production in Northern Ontario was aggregated to the primary watershed level.

UNCERTAINTY

Allocation of production from county to watershed assumes that production occurs without any spatial variability. This introduces some obvious error in production allocation. For example, York Region extends from Lake Ontario to Lake Simcoe and is comprised of watersheds 2EC in the north and 2HC in the south. Watershed 2HC is comprised largely of urban areas whereas watershed 2EC is almost exclusively an agricultural area. The methodology described above does not incorporate these variations within counties and allocates agricultural production of York Region to 2HC and 2EC based on area alone.

As mentioned, the problem of allocation is exacerbated in Northern Ontario. The solution in this case was to aggregate the watersheds to main division level and to conduct the I/O analysis at a lower level of spatial disaggregation.

POTENTIAL REFINEMENTS

The agricultural production statistics could be refined by combining these data with georeferenced county soils maps and other agricultural land use data available. A reasonable correlation exists between crop type, level of production and agricultural soil type. In some cases, this correlation can be augmented by township-specific data.

Another data gap is the lack of information on agricultural inputs geographically. These inputs, when combined with the local biophysical conditions, can strongly influence environmental contaminant loads from non-point sources. The potential for incorporation of these data is not known.

B.2 Data summary sheet — air emissions

SOURCE(S)

Ministry of the Environment. 1992. *1987 Process Emission Estimates by Industrial Point Sources.* Toronto: Air Resources Branch, Ontario Ministry of the Environment.

CONTACT

Mr. Robert Bloxam
Air Resources Branch
Ontario Ministry of the Environment
Air Quality and Meteorology Section
Etobicoke, Ontario
M9W 5L6

DATA FORMAT

- Year
- SIC code
- Longitude
- Stack code
- SCC description
- NO_x metric tonnes
- Data year
- Plant name
- SIC name
- Latitude
- SCC code
- SO_x metric tonnes
- VOC metric tonnes

The Year field contains information on the year that the inventory was calculated for. The Data Year field contains information on the base year (eg. emission factors and energy use)

GEOGRAPHICAL INFORMATION

Geographical information is provided by:

- longitude; and
- latitude

DATA PROCESSING

Point sources were summed by SIC and then by county and by watershed using point polygon searches with the GIS.

UNCERTAINTY

Emissions data were decoded and estimated from a survey questionnaire or from other sources within the Air Resources Branch (ARB) Ontario Ministry of the Environment (OMOE)[1]. The emission factors from the following documents are used in estimating emissions in the database:

i) *USEPA - AP-42 emission factors.*
ii) *USEPA - Air facilities NAPAP emission factors.*
iii) *Environment Canada - Method manual for estimating emissions.*

These emissions data were last updated in early 1991. The ARB indicated that some of these data are under revision and will be revised. There are two primary sources of uncertainty:

- the accuracy of the energy use data for each process defined as a point source in the database; and
- the accuracy of the emission factor used.

The accuracy of the emission factor itself is determined by several factors:

- the similarity of the process inventoried and the process that was used to calculate the emission factor (eg. similar fuel, similar combustion system, similar emissions controls; etc.); and
- temporal variability. (e.g. two identical boilers will have different total emissions if one is operated continuously and one is operated intermittently. The process inventoried must generally operate continuously for a steady state emission factor to be applicable).

During the course of other projects in which these data have been used, some of the specific total emissions estimates provided for SO_x, NO_x and VOCs in the database were identified as either too low or too high. In several cases, these errors were two orders of magnitude above or below what industry representatives indicated as the true emissions quantities.

POTENTIAL REFINEMENTS

Efforts are underway to update and verify many of the major emission sources in this database. These refined values should be used when available.

Air emissions from non-stationary sources and non-industrial sources are not included. Various methods to approximate these emissions are available. The additional emissions estimated using these methods would improve the comprehensiveness of this database.

---

[1] The methodology for calculating the estimates are provided in a text file that accompanies the databases provided by the Air Resources Branch, OMOE.

B.3 Data summary sheet — wood fibre production

SOURCE(S)

Ministry of Natural Resources (MNR), Forestry Management Information Section.

CONTACT

Mr. Trevor Isherwood
Director
Forest Products and Marketing Branch
P.O. Box 1000, 258 Queen Street East
Sault Ste. Marie, Ontario
P6A 5N5

DATA FORMAT

- management unit number
- age class (AC20)
- GTV (gross total volume)
- CAI (cumulative annual increment)
- working group
- area (hectares)
- NMV (net merchantable volume).

GEOGRAPHICAL INFORMATION

The Management Unit Number refers to a Forest Management Unit. The Forest Management Unit Base Map is available from the MNR.

DATA PROCESSING

An electronic base map of the Forest Management Units was obtained from the MNR. The map was overlaid with the county and watershed base maps using the GIS. GTV, NMV and CAI quantities were assigned to the new polygons based on an area weighting methodology similar to that described for the agricultural production database.

UNCERTAINTY

The methodology for calculating the GTV, NMV and CAI estimates in the MNR database was not provided by the MNR. An assessment of the uncertainty associated with the data is best provided by the ministry.

One additional source of uncertainty was the area weighted allocation methodology for wood quantities. The implicit assumption in the methodology is that wood quantities are uniformly distributed throughout each FMU. A more detailed study of the distribution of forest stocks within FMUs was beyond the scope of this study.

POTENTIAL REFINEMENTS

A major challenge faced in attempting to connect the wood fibre production data with the LINK model involved allocating the supply to individual forest products mills. These data are available through the individual timber management plans (around 100 plans in total within the province). However, it was beyond the scope of this study to amass these data. Local and regional wood shortages and their consequences would be more easily explored with this refinement to this database.

B.4 Data summary sheet — hazardous waste generation

SOURCE(S)

Ontario Ministry of the Environment. 1990. *Public Information Dataset Release AT1989 - 900515.* Toronto: Waste Management Branch, Special Waste & Manifest Section. OMOE.

Statistics Canada. 1987. *Standard Geographical Classification SGC 1986.* Ottawa: Standards Division, Statistics Canada.

Statistics Canada. 1991. *Postal Code Conversion File January 1991 Version.* Ottawa: Geography Division, Statistics Canada.

Environment Canada. 1986. *Active Hydrometric Stations.* Ottawa: Environment Canada (Map).

CONTACT

Not available.

DATA FORMAT

Manifest Generator Database was used. Fields included:

- Generator company number
- Address1 : site address
- Address2 : mailing address
- Postal code
- Area code
- Region
- County
- Majwast: MOE waste coding
- Handle code
- Specific gravity
- Quantity: in kg.
- Generator company name
- City : for address2
- Province
- Contact name
- Phone number
- MOE district
- GSIC
- Waste characteristic
- State
- Physical state
- SIC

- SIC group
- Waste class-OWMC waste coding
- Municipal: municipality
- IMN: geographic code
- Quantity: in tonnes
- VB Region: Regions developed for the OWMC to study waste allocation.

There are 20,131 records in the Manifest Generator Database with 841 unique cities and 6,415 unique postal codes. The database describes hazardous waste shipped offsite from generators in Ontario.

Geographical Information

Geographical information is provided by city, province, postal code, county, region, MOE district, IMN, municipality, and VB Region.

Data processing

In approximately 1,500 records in the Manifest Generator Database the site address is different from the mailing address. In these cases the city and postal code fields used for geocoding do not refer to the point of waste generation but to the mailing address. The first step in processing the data for input into the LINK model was to create an application that could parse the address1 string and extract the city or township name. Once the city field in the database was corrected, watersheds were assigned to each record by city or township using either a database created from Statistics Canada census data or, where applicable, by matching the postal code in each record to records in the Statistics Canada Postal Code Conversion (PCCF) file to extract Latitude and Longitude coordinates. Those records that were able to be assigned Lat/Long coordinates from the PCCF were then assigned to watersheds using the GIS. However, even with the city/watershed database and the PCCF some 360 townships, towns and cities had to be manually assigned watersheds. The next step in processing the data for input into the LINK model was to sum the wastes by the 14 different OWMC waste classes by GSIC (4 digit SIC code) by county and then by watershed in the RDBMS. The results were then exported to an ASCII file for input.

Uncertainty

Correcting the city field to adequately represent the site location removed the chief source of error. Geocoding the database using the PCCF was also subject to error since the postal code was for the mailing address. As discussed above, where appropriate the city/watershed mapping database created from Statistics Canada census data was used to assign watersheds to each record. Where the postal code accurately identified the site location the PCCF was used. There were cases where it was not possible to use either method. These cases were the result of a postal code not being provided in either the Manifest Generator database or in the PCCF or a city or township not appearing in the city/watershed database. In these cases the city or township had to be located by hand on a map and assigned a watershed.

POTENTIAL REFINEMENTS

A requirement for connecting economic activity to site-specific environmental concerns (e.g., watersheds) requires accurate geo-referencing of the location of economic activity. Rudimentary geo-referencing of certain key economic activities has been undertaken as part of this research project. Considerable refinement could be achieved, in this case, with respect to the location of hazardous waste generation. The assignment of Latitude and Longitude coordinates, based on the postal code location of firms, appears to be a promising approach to obtaining improved georeferencing of economic activity.

B.5 Data summary sheet — mineral production and deposits

SOURCE(S)

Ministry of Northern Mines and Development. 1991. *Ontario Mineral Score 1989.* Toronto: Mineral Development and Lands Branch.

The Northern Miner. *Canadian Mines Handbook 1991-92.* Toronto: Southam Business Communications Inc.

Energy, Mines and Resources Canada, Mineral Policy Sector. 1992. *Mineral Deposit Information System (MINSYS).* Ottawa: Economic and Financial Policy Analysis, Mineral Policy Sector, EMR.

CONTACT

a) Dario Romani
Planning and Information Office
Ontario Ministry of Northern Development and Mines
4th Floor, 159 Cedar Street
Sudbury, Ontario
P3E 6A5

b) Jaques Savard
Energy, Mines and Resources Canada,
Mineral Policy Sector
Ottawa, Ontario
K1A 5H3

DATA FORMAT

a) Hardcopy. Fields included:

- Municipality
- Mineral commodity
- Units
- Volume
- Value (dollars)

b) Electronic database format. Fields included:

- Minsysno (unique identifier for each deposit)
- Latitude
- Longitude
- Commodity.

GEOGRAPHICAL INFORMATION

Geographical information was available by:

- County
- Latitude, longitude, geological province, UTM (Northing and Easting)

DATA PROCESSING

Mineral production by commodity by county was readily available from the *Ontario Mineral Score* (See ref. a). However, commodity production by watershed required that individual mineral production operations had to be identified and mapped manually. The identification of individual operations within the watersheds involved using the *Canadian Mines Handbook* and MINSYS.

UNCERTAINTY

Mineral production within counties occurs in operations that may be all co-located in one watershed or may be dispersed over several watersheds. Since data for production of minerals is provided by county aggregates, total production had to be apportioned to individual operations to reaggregate by watershed. Data for individual operations are limited to tonnes of raw ore handled per day (Northern Miner 1992). Consequently, the only option for assigning individual operations annual production quantities relied on prorating mineral production based on daily raw ore handling capacity.

The inherent source of uncertainty associated with this methodology is that there is no consideration of ore quality; all ores mined within a county are assumed to be of equal grade.

Consequently, the actual mineral production by watershed may be misrepresented using this methodology.

POTENTIAL REFINEMENTS

An important aspect of sustainability is the rate of non-renewable resource consumption and available supplies. Strict definitions of deposits are applied in the mining industry that are based on prevailing market conditions, current technology and the quantity and quality of the deposit. These are important characteristics of a deposit if, for example, an analysis of the sustainability of the Ontario mining industry were examined. While the required data are available, compilation, synthesis and integration in the existing model would require considerable effort.

The geographic location and nature of existing mining operations could be improved by broadening the basis and methodology for apportioning production among establishments.

B.6 Data summary sheet — municipal sewage generation

SOURCE(S)

Ministry of the Environment. 1991. *Report on the 1989 discharges from sewage treatment plants in Ontario.* Toronto: Water Resources Branch and MISA Municipal Section, Project and Data Management Section, Systems and Information Branch.

Various maps of sewage treatment plant drainage areas throughout Ontario.

CONTACT

Not available.

DATA FORMAT

- Plant_no (plant number)
- Dtype
- Name
- Region number
- Month
- Aflow
- Peak rate
- Flow_dura
- Bodeff
- Critbod
- Ssinf
- Remss
- L_ss
- Plant type
- Municipality
- Region name
- Treatment
- Tflow
- Mflow
- Tflow_eff
- Bodinf
- Rembod
- L_bod
- Sseff
- Critss
- Tpinf

- Tpeff
- Crittp
- Op_nm
- Remtp
- L_tp

GEOGRAPHICAL INFORMATION

Geographic information was available by:

Region name, and municipality.

DATA PROCESSING

The sewage system maps from the public works departments of the following municipalities were collected:

- Brampton
- East Gwillumbury
- Keswick
- Mount Albert
- Ottawa
- Sutton
- Whitby
- York
- Cambridge
- Hamilton
- London
- Oakville
- St. Catharines
- Toronto
- Windsor.

The maps were digitized with each STP appearing as a point and its associated drainage area represented by a polygon. The STP point entities were then assigned the appropriate attributes from the STP influent/effluent data.

The STP drainage polygons were also used in the STP regression analysis. Industries located within STP drainage polygons were assumed to discharge to the STP associated with the polygon.

UNCERTAINTY

There was some uncertainty associated with the actual boundaries of the sewage drainage area for each STP. Many of the maps used were dated and many of the municipalities that provided maps indicated that the boundaries had changed significantly since publication. This was especially true in regions experiencing rapid growth (eg. York Region).

A considerable volume of data has been compiled by the Ministry's MISA Office which was not completely assessed. These data would greatly improve the ability to assign sewage generation from economic activities to specific areas. Also, data for many contaminants, in addition to the conventional contaminants reported annually, have been collected. Ideally, the loadings of these containments by individual dischargers as a function of economic activity would be useful for the model.

Much work was spent delineating and geographically coding boundaries for sewage treatment plants. These data are useful for a range of environmental planning and management tasks and a systematic program to prepare a comprehensive machine-readable database would provide many benefits.

B.7 Data summary sheet — industrial water consumption

Source(s)

Environment Canada. 1986. *Industrial Water Use Data for Ontario.* Ontario: Water Planning and Management Branch.

Contact

Not available.

Data format

Electronic spreadsheet format. Fields include:

- RSN
- Standard geographic code
- Status
- Municipality
- Days worked
- Total intake
- January intake...
- January discharge...
- Cost of water acquisition
- Cost of intake license
- Source: self-supplied (fresh)
- Other sources (fresh)
- Self-tide (brackish)
- SIC
- Hydrometric code
- Name
- Employees
- Hours worked
- Total discharge
- December intake
- December discharge
- Operating maintenance cost
- Source: public utility (fresh)
- Source: self-supplied groundwater (fresh)
- Source: self-supplied groundwater (brackish)
- Other (brackish).

Geographical Information

Geographic information was available by:

Standard geographic code, Hydrometric code, municipality

Data processing

Water-use quantities were summed by SIC by county and by watershed.

UNCERTAINTY

Not available.

POTENTIAL REFINEMENTS

Not available.

Appendix C.

Suggested treatment of natural resource accounts in the LINK model

C.1 Introduction

The major weakness in the conventional treatment of natural resources in national accounts is that the measured value of production does not take resource depletion into account and, as a result, is overstated (Repetto, et. al. 1989; El Serafy 1989). It has been suggested that depletion of natural resources be deducted from gross domestic product (GDP) in a manner similar to the deduction of capital consumption allowances (depreciation of fixed capital) in the calculation of net domestic product (NDP) (Repetto, et. al. 1989). Here, it is argued that, at least for mineral resources, the parallel treatment of depreciation of fixed capital and depletion of natural resources is inappropriate. Further, the conventional treatment of mineral resource extraction in national accounts overstates GDP as well as NDP. An alternative treatment of mineral resources is suggested below. This treatment is similar in some respects to the proposals of Bartelmus (1990). Subsequently, both the depreciation allowance approach used for fixed capital and the suggested depletion approach for mineral resources are considered in the treatment of various types of renewable resources. In the following section, the basic structure of national accounts is reviewed, based on Canadian practice. In section C.3, the treatments of fixed capital and mineral resources are discussed, and in section C.4 the treatment of renewable natural resources is considered. A brief discussion of pricing appears in section C.5, and conclusions and unresolved issues are discussed in section C.6.

C.2 National accounts—the Canadian system

In the Canadian system of national accounts (SNA), the national income and expenditure accounts (NIE) are subdivided in two ways: by sector (persons, governments, businesses and non-residents) and by type of activity (production, income and outlay, and capital finance) (see Statistics Canada 1975, 13-549E, National Income and Expenditure Accounts, Volume 3, a Guide to the National Income and Expenditure Accounts. Definitions-Concepts-Sources Methods.) While the definitions of sectors are self-evident from the sector names, it is useful to examine the classification of transactions by activity in some detail.

The production account records receipts from sales of goods and services and payments for costs of production including intermediate goods and services produced domestically (including competing imported products), imported goods and services for which there are no domestically produced counterparts (non-competitive imports), indirect taxes paid on purchased inputs (net of subsidies), wages and salaries, and employee benefits (supplementary labour income). The account is balanced by the cost item operating surplus.

The income and outlay account records receipts (sources) of income such as operating surplus (business), labour income (persons), interest and rent income (all sectors) direct and indirect taxes received (government) and other transfers received (all sectors); and payments (uses of income) such as purchases of final goods and services (all sectors), rent and interest payments (all sectors), direct taxes paid (business and persons), capital consumption allowances (all sectors) and other transfers paid (all sectors). The balancing item in the income and outlay accounts is saving, which, if positive, represents the amount of income available to finance acquisition of additional assets (capital) or, if negative, represents the degree to which assets have been reduced in order to finance current spending or subsidize production.

The capital finance account records saving and capital consumption allowances as sources of funds, while uses of funds include acquisition of real assets, consisting of gross fixed capital investment, the value of the physical change in inventories and net purchases of existing real assets, and the net acquisition of financial assets. Capital gains or losses on assets are not included in the accounts, on the grounds that they are not based on productive activity. If they were included, they would appear as sources (gains) or uses (losses) of funds in the income and outlay accounts and thus affect saving and would also appear as positive uses (gains) or negative uses (losses) in the capital finance accounts.) Every transaction appears twice in the accounts; both as a source of funds to one sector and as a use of funds to the same sector or other sectors.

The calculation of GDP is based on the production accounts of all domestic (physically located within the country) business (non-corporate, corporate and government) as well as households and governments and is a measure of the value of production taking place within the physical boundaries of the country. GDP is equal to the total value-added in production (indirect taxes, labour income and operating surplus) which, in turn, equals total domestic spending on final product plus exports less imports. This result can be better understood by examining the detailed presentation of the production account which appears in input-output tables. The Canadian Input-Output data (Statistics Canada 15-510) is organized on a commodity by industry basis, which means that sales of products are identified by commodity and producing industry (in a "make" matrix) and that purchases of products are identified by commodity and purchaser. Purchases of intermediate products by businesses are classified by purchasing industry and presented in a "use" matrix, which also records non-competitive imports and the value-added items (indirect taxes, labour income and operating surplus) for each industry. The use matrix represents the cost or uses of funds side of the production accounts, while the make matrix represents the sales or sources of funds side of the production accounts. Purchases of final products, classified by commodity, appear as uses of funds in the income and outlay accounts of persons (personal consumption expenditures), governments (government current expenditure) and non-residents (domestic exports of goods and services, excluding investment income) and in the capital finance accounts of businesses and governments (gross fixed capital formation and inventory investment). These purchases of final product are presented in a third input-output matrix, the "final demand" matrix. For statistical purposes it is difficult to identify the domestically produced and imported components of purchases of traded commodities by specific users, but it is easier to identify the total imports of each traded commodity. For this reason all purchases of traded commodities in the use and final demand matrices include competing imports and the total import of each traded commodity appears as a negative item in an imports column in the final demand matrix. The imports column also contains a negative item representing the total non-competitive imports so that the (negative) column total represents all imports.

Sectoral income may be identified as the total source of funds in the sectoral income and outlay accounts. National income can be measured by consolidating the sectoral accounts for the three domestic sectors (persons, governments and businesses). All transfers between the domestic sectors will net out, leaving GDP (indirect taxes, labour income and operating surplus) plus net transfers (including investment in come) received from non-residents, which is usually called gross national product (GNP). The terminology used for GNP is unfortunate because it leads to a confusion between the measure of production (GDP) and the measure of income (GNP). Here, GDP will be treated exclusively as a measure of the value of production and the proposed changes to GDP measurement are intended to provide a better measure of production.

C.3 Fixed capital and mineral resources in national accounts

The term *fixed capital* refers to residential and non-residential construction, and machinery and equipment. Fixed capital (together with inventories) represents products of the economy which are used to provide "services" which aid in future production. As such they are "real" assets, which are valued for the services they provide. The purchase of new fixed capital (gross fixed capital formation) represents one use of the final product of the economy. In terms of the accounts it is a part of the sales of product in the production account of business and is also entered as a purchase of an asset in the capital finance account of the purchasing sector. This is illustrated by the following simple example (Figure C-1) in which the value of machinery sold is 80 and the purchase is financed by business saving of 80. The costs of production of the machinery are assumed to consist of purchases of primary metal (40) and labour (20), leaving operating surplus of 20 as a residual. Because the input of primary metal is a produced good, it is necessary to show the production accounts representing its production. For these purposes we add a primary metals industry, whose sales of metal (40) are offset by purchases of ore (20), labour (10) and operating surplus (10). Since the ore is produced (extracted) by a mining industry, the extraction costs must also be accounted for as labour (5) and operating surplus (15). The SNA procedures do not explicitly identify the value of the mineral deposit as a cost of production, so that this value is implicitly included in the operating surplus of the mining industry.

The transactions in the production account can also be presented in an input-output framework (Figure C-2). The costs of each industry are shown in the use matrix, which is presented beside the final demand matrix (In this example, the make matrix is a diagonal matrix showing the value of commodities sold by each industry.) In this example GDP is equal to 80 and can be calculated either by the total value-added or the total deliveries of domestic product to final demand.

Now suppose that there had been depreciation of fixed capital (machinery) over the production period and that this depreciation was accurately measured by capital consumption allowances totalling 20 for the three industries combined. In the Canadian accounts, the capital consumption allowances appear as uses of funds in the income and outlay accounts and as sources of funds in the capital finance accounts. These two accounts would now appear as shown in Figure C-3,

BUSINESS PRODUCTION ACCOUNTS

Mining industry

Purchases		Sales	
Labour	5	Ore	20
Operating surplus	15		

Primary metals industry

Purchases		Sales	
Ore	20	Metal	40
Labour	10		
Operating surplus	10		

Machinery industry

Purchases		Sales	
Metal	40	Machinery	80
Labour	20		
Operating surplus	20		

Business income and outlay account

Uses		Sources	
Saving	80	Operating surplus	45
		Other income	35

Business capital finance account

Uses		Sources	
Purchases of machinery	80	Saving	80

Figure C-1 Example of gross fixed capital formation in the Business production, income and outlay, and capital finance accounts (Values are hypothetical)

where business saving (Figure C-1) has been reduced by the amount of the capital consumption allowance.

Since fixed capital is a produced asset, i.e., a product of the economy in previous periods, it is reasonable to net out the depreciation of fixed capital against gross fixed capital formation to calculate the net increase or investment in fixed capital (which equals saving in Figure C-3). Similarly, the depreciation can be subtracted from GDP to arrive at net domestic product (NDP), which reflects the fact that some fixed capital (a produced asset) has been used-up in the production process.

Several authors (Repetto, et al. (1989) and El Serafy (1989) among others) have suggested that, following the procedure used to account for depreciation of fixed capital, depletion allowances for extracted mineral deposits should also be deducted from GDP in the calculation of NDP. However, mineral resources differ from fixed capital in two important ways. First, mineral resources are not products of the economy but instead are provided by nature. The concentration of molecules of metal in sufficient quantities to make extraction profitable was accomplished by nature and not by man. While the profitability of extraction of a particular deposit is affected by both technology and prices, the existence of the deposit is an act of nature. To the extent that the nature of the deposit can be altered by man in order to facilitate extraction, this should be considered as a part of the extraction process and, thus, as production. Second, mineral resources are completely transformed by production, and, in this way, are unlike fixed capital which

	Industry use			Business investment	Total
	Mining	Primary metal	Machinery		
Output					
Ore (flow)		20			20
Metal			40		40
Machinery				80	80
Value added					
Labour	5	10	20		35
Operating surplus	15	10	20		45
Total value added	20	20	40		80
Industry output	20	40	80		
Final demand				80	
GDP					80

Figure C-2 Example of gross fixed capital formation in the input-output accounts (Values are hypothetical)

Business income and outlay account				Business capital finance account			
Outlay		Income		Uses		Sources	
Capital consumption allowances	20	Operating surplus	45	Purchase of machinery	80	Saving	60
Savings	60	Other income	35			Capital consumption allowances	20

Figure C-3 Example of capital consumption allowances in the business income and outlay and capital finance account (Values are hypothetical)

continues to retain its characteristics and to provide the same services (perhaps at a declining rate) for many periods. In these ways mineral resources are like intermediate products. The closest analog to mineral resources in the SNA framework is non-competitive imports. They are treated as a cost of production, but they represent neither domestically produced intermediate goods nor domestic value-added in production. The part of the value of the extracted mineral which represents the value of the mineral deposit or ore-in-the-ground (the resource rent) is not a result of extraction (a production activity) and should not be counted as a part of value-added in production. The mineral deposit is also not a domestically produced intermediate input (being rather a product of nature). These arguments suggest that the resource rents on minerals should be treated in a manner similar to the treatment of non-competitive imports.

This treatment is illustrated first in the context of the input-output tables (Figure C-4). In this example, we suppose that the resource rent on the mineral deposit or ore-in-the-ground is 10, leaving operating surplus of 5 in the mining industry. The resource rent also appears as a negative entry in a mineral resource column in the final demand matrix so that, relative to the earlier example, the total final demand is reduced by the same amount as value-added. Measured GDP now equals 70 and has been reduced by the value of the depletion of the un-extracted mineral.

	Industry use			Final demand		Total
	Mining	Primary metal	Machinery	Mineral depletion	Business investment	
Output						
Ore (flow)		20				20
Metal			40			40
Machinery					80	80
Mineral deposit (flow)	10			-10		0
Value added						
Labour	5	10	20			35
Operating surplus	5	10	20			35
Total value added	10	20	40			70
Industry output	20	40	80			
Final demand				-10	80	
GDP						70

Figure C-4 Example of proposed treatment of mineral resources in the input-output accounts (Values are hypothetical)

The negative mineral depletion item in the final demand matrix represents the negative investment or reduction of the stock of the mineral resource which is the direct result of the production activity (mineral extraction). This item should also appear in the capital account of the owner of the mineral resource. If we assume that the mining industry owns the mineral rights to extract the deposit, this item would appear in the capital account of the mining industry, as shown in Figure C-5.

Business production account				Business income and outlay account				Business capital finance account			
Purchases		Sales		Outlay		Income		Uses		Sources	
Mineral deposits	10	Machinery	80	Capital consumption allowances	20	Operating surplus	35	Purchase of machinery	80	Saving	50
Labour	35			Saving	50	Other income	35	Sales of mineral deposits	-10	Capital cons-umption allow-ances	20
Operating surplus	35										

Figure C-5 Example of treatment of gross fixed capital formation, capital consumption allowances and mineral depletion in the business accounts (Values are hypothetical)

Mining production account				Mining capital finance account			
Purchases		Sales		Uses		Sources	
Mineral deposit	10	Ore	20	Purchases of mineral deposit	-10	Saving	-10
Labour	5						
Operating surplus	5						

Figure C-6 Example of treatment of mineral extraction in the mining industry (Values are hypothetical)

The capital finance account in Figure C-5 shows the reduction of unextracted ore as a negative saving which could be used to finance the accumulation of other assets (an offsetting positive item in uses of funds in the capital finance account), consumption (a positive item in the uses of funds side of the income and outlay account) or a negative operating surplus (a negative item on the sources of funds side of the income and outlay account. The overall business production accounts shown in Figure C-4 are also modified as shown in Figure C-6. Here, the purchase of machinery has been partially offset by the loss of the mineral deposit, reducing the increase in assets, and saving and operating surplus have been reduced by a corresponding amount. The proposed measures of both GDP (70), business income (70), business gross investment (70), business investment (50), and business saving (50) now take depletion of the stock of mineral resources into account and as a result, provide more accurate measures.

A similar procedure has been proposed by Bartelmus (1990) to calculate "sustainable GDP". Here, it is argued that this procedure provides a more accurate measure of actual GDP.

Before moving on to consider the treatment of renewable resources, several other issues regarding mineral resources need to be addressed. The first is the question of how the resource rent on extracted deposits is to be calculated. Landefeld and Hines (1985) discuss three methods: 1) the present value of future net revenues; 2) the transaction value of purchases of the mineral deposits; and 3) the net price or value of the extracted ore net of extraction costs including a "normal" return on fixed capital. If resource markets are competitive and in long-run equilibrium (no potential gains from arbitrage) these three measurements should be equivalent. The transaction value (2) should equal the present value of future net revenues (1) since the present value is the benefit gained by a purchaser of the deposit. Similarly the net rent (3) is the gain from extraction, which should equal the gain from leaving the ore in the ground and extracting later, which is the present value (1).

Calculation of the present value requires the statistician to make guesses concerning the future prices of ore and future rates of return on investment, while the transaction value represents the average market participant's guesses about these factors. Since the average market participant's guesses are likely to be less arbitrary than the guesses of the statistician, the transaction value (2) is preferred to the present value (1) as a basis for calculating resource rents. Unfortunately, mineral deposits differ in both unit extracting costs and in the quality of the extracted ore so that the transaction value will differ across deposits. Since all deposits are not sold immediately before extraction the average transaction value of deposit purchases may not equal the average transaction value of extracted deposits. However, these quantitative differences in deposits will be reflected in a calculation of net price or rent on mineral deposits. Differences in the quality of the extracted ore will be reflected in the price per unit at which it is sold. Differences in extraction costs will be explicitly captured since these costs are deducted in the calculation of net price. Thus the total value of sales of extracted ore less the total costs of extraction should equal the total resource rent on extracted mineral deposits. For these reasons the net price method is the most accurate of the three methods for the purpose of calculating the resource rent on extracted mineral deposits.

The only potential difficulty with the net price method is that the normal rate of return on fixed capital in the mining industry must be estimated in order to calculate the extraction costs. If measured rates of return on fixed capital in mining are based on an inadequate treatment (underestimate) of resource rents on extracted deposits then this rate of return on capital will be overstated and resource rents understated. The basic difficulty is that both resource rent and the rate of return on capital cannot be calculated as residuals. Thus, if the net price method is to be used to measure resource rent, the rate of return on fixed capital in mining must be based on returns to fixed capital in other industries, appropriately adjusted for risk.

Another important issue in the treatment of the mining industry in national accounts is the role of exploration. The preceding discussion has focused exclusively on extraction, yet exploration is also an important part of mining activity. Mineral exploration is not a production activity in the usual sense since the only "product" is information concerning the location, extent and quality of mineral deposits. This information certainly affects the value of mineral rights in various locations, but it does not create mineral deposits. In some ways, mineral exploration is similar to research and development activities and this similarity is reflected in the Canadian accounts. Canadian national accounts treat most mineral development and exploration expenditures as gross fixed capital formation (Statistics Canada (1975), pages 71 and 84). This treatment applies to any expense which creates a physical facility, such as construction or drilling. Expenses which solely create information, such as geological surveys, are not treated as expenditures on fixed capital, and instead are treated as outlays on production (intermediate inputs) in the business production account, similar to the treatment of research and development expenditures. This treatment follows business reporting practice but is clearly inappropriate since these expenses are not part of the costs of mineral extraction in the current period. Since operating surplus is calculated as a residual, the SNA treatment of mineral exploration (and research and development) expenditures reduces measured GDP below its true value. The logic behind the Canadian treatment is that development and drilling expenditures create physical assets and, therefore should be treated as fixed capital investment while expenditures which provide only information do not create physical assets and should not be treated as fixed capital investment. The alternative of treating these expenditures as outlay in the income and outlay accounts does not appear to have been considered. In practice some part of the development and drilling expenditure does provide information, for example, by converting probable reserves of oil to proven reserves.

The more interesting issue is the theoretically appropriate treatment of expenditure which creates information such as mineral exploration or industrial research and development. Clearly these activities have economic value or they would not be undertaken. The information provided by mineral exploration identifies both quantities and qualities of deposits. The immediate economic consequences of new information concerning mineral deposits are increases (or decreases) in the value of mineral rights. These private consequences also correspond to increases (or decreases) in the wealth or income generating potential of a nation and should in some way be incorporated in national accounts.

One potential approach would be to value this activity at cost, implying that (at least on average) the benefit of the new information gained was exactly equal to the cost of obtaining it. This would be consistent with long-run equilibrium if the marginal return to exploration was constant (independent of the level of exploration expenditure). However, if the marginal return to exploration declines with exploration expenditure the total benefit of exploration will exceed the cost so that using cost to value exploration activity will understate its value. Additional complications are that the return to exploration is uncertain so that the benefit varies across exploration activities with equal cost and that over time information gained in the past may contribute to the benefit of exploration by identifying both more and less attractive areas for future investigation.

An alternative to the cost approach recognizes the risk in the benefit of exploration activity by valuing increases in mineral reserves explicitly as well as treating the costs of exploration explicitly. This approach is illustrated in Figure C-7, where exploration expenses are assumed to equal 10 and new discoveries to have a value of 20. Exploration is treated as a current outlay of business and reduces business saving by an equal amount. The value of discoveries (or value of revised reserves) is treated as a use of funds in the capital finance account and a source of funds in the income and outlay account. There is no necessity that the cost of mineral exploration (10) equal the value of discoveries (20). Whenever the value of discoveries exceeds exploration cost, saving and asset accumulation are increased; and, whenever the value of discoveries is less than exploration cost, saving and asset accumulation are decreased. This treatment avoids the difficult problem of assigning a capital value to exploration expenditures.

Since mineral exploration is to be treated as an outlay in the business income and outlay accounts, it should also appear as a use of final product in the final demand matrix of the input-output accounts. This entry could take the form of a mineral exploration column in the final demand matrix. Since the exploration must be produced, a mineral exploration commodity (10) could be added as an output of the mining industry in the make matrix, and the value-added in producing this commodity added to the value-added of the business sector (say labour by 10 to a total of 45). In this way both total value-added and total final demand will be augmented by the same amount. Exploration must also be financed. In Figure C-7, it is assumed that exploration is financed by a sale of other assets. Some other source of financing for exploration activity is necessary because the new reserves must be sold before they can finance any activity.

Business production				**Business income and outlay**				**Business capital finance**			
Purchases		**Sales**		**Uses**		**Sources**		**Uses**		**Sources**	
Mineral deposit	10	Machinery	80	Capital consumption allowances	20	Operating surplus	35	Purchase of machinery	80	Savings	60
Labour	45	Mineral exploration	10	Mineral exploration	10	Other income	35	Sales of mineral deposits	-10	Capital consumption allowances	20
Operating surplus	35			Saving	60	New reserves	20	New reserves	20		
								Sale of other assets	-10		

Figure C-7 Example of suggested SNA treatment of mineral exploration (Values are hypothetical)

The capital finance accounts provide a basis for keeping track of resource stocks in the SNA. The uses-of-funds side of the capital finance accounts records changes in the assets of each sector of the economy and, when aggregated for all domestic sectors, it records the changes in the assets of the domestic economy. These changes in assets can be added to initial stocks to arrive at final stocks of assets. In Canada, these stocks are recorded in National Balance Sheet Accounts or NBSA, which are a component of the SNA (see Statistics Canada 13-585E. 1989. *A Guide to the Financial Flow and National Balance Sheet Accounts* for a description of these accounts). Since the Canadian accounts do not record either the discovery or depletion of mineral resources, these do not appear in the NBSA (However, the NBSA do include a category - Net Purchases of Existing and Intangible Assets - which includes land, mineral and timber rights together with used fixed capital). If the treatment of mineral depletion and discovery suggested above were adopted, the values of mineral stocks could also be tracked in the NBSA.

Two related issues remain to be discussed. If our ultimate interest is to link economic activity to physical or "real" measures of natural resource stocks, how can these be derived from changes in values of stocks, which combine both physical changes and changes in prices of resource stocks? A natural response, which is based on the treatment of inventory change in the SNA, is to estimate the capital gains portion of the change in value and attribute the remaining portion to a change in quantity. Thus one issue is how to consistently 'deflate' or remove the effect of price changes in all elements of the accounts. A second related issue is the possibility that there may be "real" capital gains, which should be reflected in the SNA. For example, suppose that scarcity causes the price of a particular mineral deposit to increase relative to the prices of other assets. This will result in an increase in the "real" value of the mineral rights to the deposit - a "real" capital gain. Because the economy which holds the deposit is better off as a result of the new price structure and because the "real" capital gain may be a basis for calculating the benefit to the economy, the capital gain should appear in the SNA.

Portions of the Canadian SNA are already 'deflated', in particular those associated with the input-output system (see, Statistics Canada 15-511). Because the input-output system is organized on a commodity by industry basis, the calculation of a price index for each commodity in the system is a natural starting point. These price indexes can be used to deflate all commodity elements in the make, use and final demand matrix. The deflated elements of industry commodity outputs in the make matrix add to a deflated industry gross output and thus, imply an industry price index. In the use matrix, after commodity inputs and non-competitive imports have been deflated, a "deflated" domestic value-added (GDP) is calculated as a residual for each industry, based on the deflated industry gross output from the make matrix. In principle in our proposed modification to the SNA, deflated resource rents on non-renewable resources can be calculated and deducted in order to arrive at a better measure of deflated GDP. There are two possible ways to calculate deflated resource rents, depending on the method used to calculate the undeflated value of resource rent (see above). If rents are calculated based on market prices of transactions in mineral rights, then an index of these prices can be calculated and used to deflate the value of resource rents. However, if resource rents are calculated as a residual (as recommended above) then deflated values of all other cost components and of gross output in mineral extraction can be calculated and "real" resource rent can be determined as a residual. This approach requires deflation of the return to capital. This can be accomplished by calculating a price index for capital goods for each industry and using this price index to deflate the nominal return to capital. Elements of the final demand matrix can also be deflated using commodity price indexes, a price index for non-competitive imports and wage indexes. In our proposed modification of the SNA, this includes elements for mineral depletion and mineral exploration, together with gross fixed capital formation.

Deflation of the input-output system also implies deflation of elements of other portions of the accounts, in particular, operating surplus and mineral exploration in the business income and outlay account and gross fixed capital formation and mineral depletion in the business capital finance account (refer to Figure C-7). A deflated value of capital consumption allowances is implicit in constant price values of gross fixed capital formation and net fixed capital formation which are prepared as a part of capital stock measurement (see, Statistics Canada 13-568, *Fixed capital flows and stocks*). The value of mineral discoveries (new reserves) can be deflated using a price index for mineral deposits which could be derived from transactions prices or values of net rents (see above). Deflation of other income in the business income and outlay account would allow subsequent calculation of deflated saving as a residual in the income and outlay accounts. Alternatively, the sale of other assets in the business capital finance account could be deflated and deflated saving could be calculated as a residual in the business capital finance account. The above steps would result in a completely deflated SNA.

The above discussion of deflation provides a background for the consideration of "real" capital gains. Nominal capital gains on assets can easily be introduced into the SNA by including them as sources of income in the income and outlay accounts and as increases in values of assets in the capital finance accounts. Saving will increase accordingly, as it represents the balancing item in both accounts. This treatment of capital gains is illustrated in Figure C-8, assuming a capital gain on mineral deposits equal to 10.

Business income and outlay account				**Business capital finance account**			
Uses		**Sources**		**Uses**		**Sources**	
Capital consumption allowances	20	Operating surplus	35	Purchase of machinery	80	Saving	70
Mineral exploration	10	Other income	35	Sales of mineral deposits	-10	Capital consumption allowances	20
Saving	70	New reserves	20	New reserves	20		
		Capital gain on mineral deposits	10	Sale of other assets	-10		
				Capital gain on mineral deposits	10		

Figure C-8 Example of incorporation of capital gains into the SNA (Values are hypothetical)

If capital gains on mineral deposits are included in the nominal SNA, then their deflation becomes a problem in creating the deflated SNA. The total increase in the value of mineral deposits is identically equal to the value of new discoveries (at end of period prices) plus the capital gain on reserves held at the beginning of the period. If each deposit at the end of each period is deflated to a "value at constant prices", then the "deflated" capital gains equal zero and disappear from the deflated accounts. Only if deposits are deflated by a price index for a different numeraire commodity or set of commodities will the deflated capital gain be non-zero.

In this circumstance it will reflect a change in the value of mineral deposits relative to the numeraire. The question then is what the numeraire should be. It could be defined in terms of some desired consumption pattern or other objective. This issue will be discussed further in section C.5.

C.4 Renewable and environmental resources

For non-renewable resources such as mineral deposits, use implies total depletion; the deposit has been removed and no longer exists as a deposit. For renewable resources, use may imply depletion but not total depletion. Trees may be cut or fish taken but natural regeneration and growth or human intervention may maintain the forest or the fishery. Here there is partial analogy to fixed capital, where use of fixed capital may reduce future use but does not preclude it. Human intervention in the form of maintenance may help sustain the services of fixed capital (the analogy is not complete because there is no natural growth or regeneration for fixed capital). It is useful to think of the flow of product - trees or fish taken - as analogous to the services provided by fixed capital and the ability of the resource - forest or fishery - to provide future flows as analogous to fixed capital as an asset. Depletion may then be considered a reduction in the ability to supply a future flow of product. To the extent that the flow of the resource into production depletes the resource, the value of gross output includes the value of resource depletion or sale of the resource. To this extent the value of production is overstated unless an adjustment is made for depletion.

Here a treatment for renewable resource depletion is suggested which parallels that for mineral resources. Resource depletion rows can be introduced into the input-output accounts, and corresponding reductions in assets can be entered in the capital finance accounts, with operating surplus, GDP and saving reduced accordingly. Expenditures for reforestation or fish stocking can be treated as final demand in a manner similar to mineral exploration, with the overall reduction or increase in the stock of the resource recorded in the capital finance and income and outlay accounts. One approach, based on an example for forest resources is presented in Figure C-10, in which forest harvest equals 20, natural growth equals 10, reforestation expenditure equals 10 and reforestation results in growth of 5 (there is no necessity that these are equal). The overall change in the stock of harvestable timber is -5; the result of depletion of -20, natural growth of 10 and growth due to reforestation of 5. In this approach the entire forest harvest is excluded from operating surplus and, as a result, from GDP.

An alternative approach, which is more consistent with the concept of depletion as a measure of the amount by which future services of the resource are compromised, would be to calculate depletion as the difference between the harvest and natural growth. If only depletion is excluded from GDP, then natural growth is implicitly treated as a part of the domestic value-added contributed by the forestry industry. If the natural growth of the forest is considered to be a product of the forested land, then this treatment is analogous to the treatment of agriculture, where the return to land is treated as a part of domestic value-added contributed by agriculture. The basic issue is whether or not the "productive" activities of nature should be treated as a part

Business production account				Business income and outlay account				Business capital finance account			
Uses		Sources		Uses		Sources		Uses		Sources	
Forest harvest	20	Sales of logs	80	Reforestation expenditures	10	Operating surplus	25	Forest harvest	-20	Saving	30
Labour	45	Reforestation expenditures	10	Saving	30	Growth due to reforestation	5	Growth due to reforestation	5		
Operating surplus	25					Natural growth	10	Gross fixed capital formation	35		
								Natural growth	10		

Figure C-9 Example of possible treatment of renewable resources (Values are hypothetical)

of the domestic productive system or as a part of a distinct natural or environmental system, as suggested by Bartelmus (1990). Both approaches lead to the same measure of the overall change of forest resources in the capital finance account and the same value of saving but to different measures of GDP. An example of this approach is presented in Figure C-10, where forest depletion is 10 (harvest of 20 less natural growth of 10).

Business production account				Business income and outlay account				Business capital finance account			
Uses		Sources		Uses		Sources		Uses		Sources	
Forest depletion	10	Sales of logs	80	Reforestation expenditure	10	Operating surplus	35	Forest depletion	-10	Saving	30
Labour	45	Reforestation expenditure	10	Saving	30	Growth due to reforestation	5	Growth due to reforestation	5		
Operating surplus	35							Gross fixed capital formation	35		

Figure C-10 Example of suggested SNA treatment of renewable resources (Values are hypothetical)

The forestry examples considered above treat the volume of standing timber as the resource stock. An alternative would be to treat the land area devoted to forests as the resource. Under Canadian conditions, and ignoring the possibility of forest-climate interactions, the entire forest could be clear-cut once each 80 years and would regenerate itself naturally between harvests. An alternative harvesting pattern would cut 1/80th of the forest each year, resulting in a constant harvest. The pattern of depletion would differ dramatically between these two alternatives yet over an 80 year period the harvest would be the same. In this example, the basic productive capacity of the forest is not affected by the harvest pattern so that harvesting cannot deplete the forest. Depletion can only occur if the forest land area declines, either through deforestation or site degradation. Depletion due to site degradation would be charged against production in the forestry industry, but depletion due to deforestation represents a transfer of the land resource to other uses.

Several other possibilities for measuring renewable resource depletion have been suggested. The first, used by Repetto, et. al. (1989), is based on a physical account of changes in the resource stock, including the harvest, which is then converted to a change in value using net rental prices. While this approach provides a useful picture of the sources of change in the resource stock, it does not tell us what portion of that change represents a depletion charge against production. The approach recommended here charges depletion against production only to the extent that the future flow of product is compromised. In the Repetto approach the entire value of the decline of the resource stock is charged against production. However, there are other sources of decline such as deforestation or natural disaster (fire) which are not the result of harvesting and should not be charged against production. In the approach illustrated in Figure C-10 only the amount by which the harvest exceeds natural growth is charged as depletion. Alternatively, a maximum sustainable yield could be calculated. If the harvest exceeds this yield, then the present value of the reduction of future yields could be charged as depletion.

The same basic principle suggested above could be applied to environmental resources such as air or water. Here, the practical difficulty is to determine the degree to which the future ability of the resource to provide services has been impaired. One difficulty is that these resources have multiple uses and that some uses such as waste disposal may compromise other uses. The impairment of other uses, both present and future, should be charged against users of these resources, either in production or income and outlay (for consumption activities) accounts.

C.5 Pricing

The procedures actually used in the SNA and the modifications proposed above rely on market prices to calculate values and to aggregate commodities and primary inputs, with balancing items calculated as residuals. This practice is certainly convenient but may not be the most appropriate. Alternatives to using market prices are considered here, particularly those which might be relevant to natural resources and sustainable growth.

If all markets were competitive and there were no externalities or public goods then, in competitive equilibrium, market prices represent social opportunity costs, at least in a static world. Even under these conditions, in the context of growth current market prices may not reflect future opportunity costs if the interests of future generations are not represented in the preferences of current generations. Thus alternatives to market valuation are of interest if they more accurately reflect social opportunity costs.

One such alternative has been suggested by Hartwick (1990). If a specific intertemporal social welfare function is chosen (Hartwick uses the discounted sum of present and future utilities), then the shadow prices from the corresponding optimization problem provide the appropriate valuation. If this idea were applied to sustainable growth, for example, by maximizing a constant flow of utility or maximizing the minimum future flow of utility, then the shadow prices from this optimization problem would represent "sustainability prices". If these prices were used to value current economic activity, including production, consumption and changes in resource stocks, then the relationship between this activity and sustainable growth would be reflected in the resulting "sustainability" accounts.

C.6 Conclusions

The treatment of natural resources in macroeconomic accounts is clarified if production, income and outlay, and capital finance accounts are both clearly distinguished and fully utilized.

For mineral resources, the rent on deposits represents the sale of a resource and should not be included in GDP, as implied by current practice. This can be accomplished by recording depletion as a sale of assets in the capital finance account and as a cost of production in the production accounts. In this way, both GDP and national saving are reduced by the amount of deposit depletion, as compared to current practice. The net rent method is suggested as the best way to measure depletion of mineral resources.

Mineral exploration expenses should be valued at cost and treated as an outlay in the income and outlay account and as a sale in the production account, implying that saving is reduced by the value of mineral exploration. New discoveries of mineral deposits should be treated as income in the income and outlay account and as an increase in assets in the capital finance account, implying that saving increases by the amount of new discoveries.

Changes in mineral deposits (and other natural resources) which are recorded in the capital finance account could be used to keep track of levels of reserves in national balance sheet accounts. Capital gains on mineral deposits should be treated in a manner similar to new discoveries, appearing in both the income and outlay and the capital finance accounts. The entire system of accounts can be deflated, following the procedure used for the input-output accounts, with deflated GDP and saving calculated as residuals. Renewable resources can be treated in the same way as mineral deposits, with depletion based on any reduction in the future flow of services from the resource. Finally, alternative (to market prices) valuation schemes could be based on long-run goals such as "sustainable growth" and would result in accounting values which accurately reflect the relationship between economic activity and these goals.

C.7 References

Bartelmus, Peter. 1990. "*Environmentally Sound and Sustainable Development: A Conceptual Framework*". mimeo.

El Serafy, S. 1989. *"The Proper Calculation of Income From Depletable Natural Resources"*, in Ahmad, Y.J., S. El Serafy and E. Lutz (eds.) (1989), *Environmental Accounting For Sustainable Development*, Washington: The World Bank.

Hartwick, J. 1990. *"Natural Resources, National Accounting and Economic Depreciation"*, DP#771. Department of Economics, Queen's University.

Landefeld, J.S. and J.M. Hines. 1985. "National Accounting for Non-Renewable Natural Resources in the Mining Industries", *Review of Income and Wealth*, Vol. 31, No. 1 (March): 1-20.

Repetto, R, W. Magrath, M. Wells, C. Beer and F. Rossini. 1989. *Wasting Assets: Natural Resources in the National Income Accounts*. Washington: World Resources Institute.

Statistics Canada. 1975. *National Income and Expenditure Accounts, Volume 3, a Guide to the National and Expenditure Accounts. Definitions-Concepts-Sources-Methods*. Cat. 13-549E. Ottawa: Statistics Canada.

_________. 1987a. *The Input-Output Structure of the Canadian Economy*, 1961-1981. Cat. 15-510. Ottawa: Statistics Canada.

_________. 1987b. *The Input-Output Structure of the Canadian Economy in Constant Prices*, 1961-1981. Cat. 15-511. Ottawa: Statistics Canada.

_________. 1989. *A Guide to the Financial Flow and National Balance Sheet Accounts*, Cat. 13-585E. Ottawa: Statistics Canada.

________. 1983. *Fixed Capital Flows and Stocks, Historical 1936-1983*, Cat. 13-568. Ottawa: Statistics Canada.

Appendix D.

Sewage treatment plant (STP) regression model

D.1 Sewage treatment plant (STP) model specifications

The STP regression model relates waste inputs to STPs to economic activity in the area served by the STP. It can be represented by the following equation:

$$I_{i,r} = A_i + (B_{i,j} \times X_{j,r}) + (C_i + D_i \times Y_r)P_r + E_{ir}, \quad (1)$$

where:

$I_{i,r}$ is the quantity (kg/yr) of input i (BUD, SS, TP) to plant r
$X_{j,r}$ is the sales of industry j located in the area served by plant r
Y_r is the per capita income of the area served by plant r relative to the average per capita income of all areas
P_r is the population in the area served by plant r

A_i, $B_{i,j}$, C_i and D_i are coefficients, and E_{ir} is a random error term.

There is one equation for each input into STPs.

These equations can be estimated individually in cross-section ordinary least squares (OLS) regressions or to increase the precision of the estimates, as a set of equations in a generalized least squares (seemingly unrelated regressions) procedure.

Estimation requires that the economic and population data be geocoded to conform to the areas served by the STPs. Alternatively, the STPs can be aggregated to the county level so that the geographic unit becomes the county.

If data are available from two or more years, then pooled cross-section and time-series regression equations can be estimated. This has the advantage of providing better estimates of the responses over time of a particular area to changes in economic and population variables.

D.2 Sewage treatment plant (STP) regression results

The objectives of these regressions are to relate the influent into STP plants to demographic and economic variables in the corresponding STP service areas. However, the difficulty in completing the allocation of economic data to STP service areas precluded the estimation of these regressions.

As such, regression results could be completed based on data giving industry gross output by industry and county and population by county from ERL and MOE data files giving influent of BOD, SS (suspended solids), and TP (total phosphorus) for 418 STPs in Ontario. The three influent contaminants to the 418 STPs were aggregated by county and used as dependent variables in ordinary least squares (OLS) regressions. Industry gross outputs and population by county were used as explanatory variables in the regression equations. The intercepts in these regression equations were constrained to equal zero, so that if there were zero values of population and industry gross outputs the equations would predict zero influent into the STP.

The results of these regression equations are shown in Table D-1. County populations had very little correlation with county STP influent, with correlation coefficients less than 0.004 for each influent. This is most likely due to wide differences across counties in the percent of county population served by the STPs in the sample. (If these percentages were the same then county population would be proportional to the population served by STPs and would be a perfect proxy for population served by STP in each county.) Further results describing the effect of population served on STP influent are discussed below. However, gross outputs for a few of the industries were more strongly correlated with the STP influent and regression coefficients for these industries are also shown in Table D-1. As is typical of cross-section regressions, R-Square values are low, ranging from a low of 0.1148 for the SS influent to a high of 0.1358 for the TP influent. Only the *Primary textile* and *Agriculture* industries show statistically significant coefficients in the regression equations for the three influent. The *Forestry* industry also has large positive coefficients in all three equations, but these are not statistically significant.

The similarity of the results for the three influent contaminants suggests that the data for the influent is highly correlated. This is borne out in Table D-2 by the very large (0.940 to 0.991) correlation coefficients between the influent variables after they had been aggregated to the county level. This close correlation could be due to similar composition of these influent across STPs in the province, but it could also be the case that many STPs are estimating BOD, SS, and TP influent by using the same constant fractions of total influent. Further examination of the STP influent data would be useful to help resolve this question. If STP plants are simply using constant percentages of total influent flow to estimate the three influent then the STP equations should concentrate on explaining total influent flow.

D.3 Conclusions

The finding that gross output in *Agriculture* has statistically significant coefficients for each STP influent is surprising, since agricultural runoff would not be expected to enter sanitary sewer systems, at least directly. If this result is correct it suggests that agricultural runoff is indirectly entering sanitary sewers.

The results reported in Table D-1 should be interpreted with caution. Further investigation using data allocated to smaller geographical units (the actual STP service areas) would be desirable. It would also be desirable to remove the approximately 200 direct dischargers who do not use sanitary sewer systems from the economic data so that it more accurately reflects potential influent into the STP. This is important because the direct dischargers tend to be large plants whose gross output may make up a significant portion of industry output at the county level.

Table D-1 STP regressions for BOD, SS, and TP influent

Industry gross output ($million 1984)	Influent loads coefficient (standard error)		
	BOD[a]	TSS[b]	TP[c]
Primary textiles	45 759	63 142	1 557
	(21663)	(50124)	(719.6)
Agriculture	28 698	39 645	980
	(13599)	(21155)	(451.7)
Forestry	40 264	50 096	1 369
	(46313)	(71591)	(1538.5)
Furniture and fixtures	-	3 538	-
		(29198)	
Refined petroleum and coal products	94	-	15
	(2210)		(73.4)
R-Square	0.1341	0.1148	0.1358

NOTES: Ordinary least square (OLS) regressions with intercept set to zero based on 418 Ontario STP's aggregated to the (49) county level economic data (industry outputs by county in 1984 prices) from ERL data files.

a - Biological oxygen demand.
b - Suspended solids.
c - Total phosphorus.

D.4 Further investigations — population served and STP influent

The relationship between population served and STP influent was also investigated using a 1989 data set for 209 STPs, which included data on population served for each STP region as well as data on total flow and influent of BOD, TSS (total suspended solids) and phosphorus. Table D-3 shows the results of OLS regression equations (intercept set to zero) showing the effect of population served on total flow and the three influent. In contrast to the data aggregated to the county level, the data for individual STP plants shows a strong relationship between population served and STP influent. Total flow is almost perfectly proportional to population

Table D-2 Coefficients of correlation between STP influents

Influent	BOD[a]	SS[b]	TP[c]
BOD	-	0.952007	0.991047
SS	-	-	0.940773
TP	-	-	-

NOTES: Based on 418 Ontario STPs aggregated to the (49) county level.

a - Biological oxygen demand.
b - Suspended solids.
c - Total phosphorus.

served, as shown by the R-Squared value of 0.95, which is unusually high for a cross-section regression. The proportionality constant is 0.67 m^3 influent per day per person served. Influent loads of the three contaminants are also closely related to population served, with R-Squared values between 0.57 and 0.60, which, again, are high for cross-section regressions. The proportionality constants for total flow and the three contaminants are highly significant, as indicated by the small standard errors. The proportionality constants (influent flow/person/day and kg/yr/person contaminant loadings) for the three contaminants are approximately 4.3, 4.9 and 0.19 kg/a per person served for BOD, TSS and phosphorus, respectively.

As in the county data set, the similarity of the results for the three contaminants suggests that they are closely related. This suggestion is borne out by the correlation coefficients reported in Table D-4. As with the county data, the correlation coefficients among the three contaminants are very high, ranging from 0.92 to 0.97. As noted above, the close relationship between data for these three variables should be investigated. Table D-4 also reports correlation coefficients between total flow and the three contaminants. These are also strongly related with correlation coefficients between 0.69 and 0.73.

Table D-3 Effect of population served on influent flow

Independent variable	**Dependent variable coefficient (standard error)**			
	Total Influent Flow	**BOD**[a]	**TSS**[b]	**Phosphorus**
	(m^3/day)	**(kg/yr)**	**(kg/yr)**	**(kg/yr)**
Population served (millions)	0.6746 (0.0102)	4.2701 (0.2444)	4.948 0.2856	0.1937 0.0106
R-Square	0.9514	0.5795	0.5766	0.6001
Observations	209	205	205	205
Degrees of Freedom	208	204	204	204

NOTE: OLS regressions with intercept set to zero of influent of BOD, TSS, and phosphorus from 209 Ontario STPs on population served.

a - Biological oxygen demand.
b - Total suspended solids.

Although total flow can be reasonably explained by population served, the results in Table D-3 and Table D-4 suggest that the inclusion of economic variables can potentially improve the explanation of the three contaminants. This can be explored if the economic data can be allocated to STP service areas.

Data describing influent of metallic contaminants is available for 37 STPs. Allocation of economic data to the service areas for these STPs would allow exploration of the links between economic activity at the industry level and influent concentrations of metallic contaminants, although the sample of 37 is relatively small for cross-section regression.

Table D-4 Coefficients of correlation between total flow and BOD, TSS and phosphorus influents

	Total influent flow	BOD[a]	TSS[b]	Phosphorus
Total influent flow	-	0.6894	0.725	0.7321
BOD	-	-	0.9282	0.9247
TSS	-	-	-	0.9713
Phosphorus	-	-	-	-

NOTE: Based on 205 Ontario STPs.

a - Biological oxygen demand.
b - Total suspended solids.

Appendix E.

Detailed scenario output

Default Environmental Coefficients Results By Sector

```
                         WATER COEFFICIENTS BY INDUSTRY
                                           Intake       Discharge    Difference
Agriculture                             0.0                 0.0000       0.0000
Forestry                                       0.0000       0.0000       0.0000
Fishing                                        0.0000       0.0000       0.0000
Mining                                      4949.0880    5639.5550    -690.4670
Food                                        2436.3330    2182.9430     253.3900
Textile                                     6744.5960    6681.8700      62.7260
Knitting                                       0.0000       0.0000       0.0000
Wood                                         725.0750     676.7982      48.2768
Furniture                                      0.0000       0.0000       0.0000
Paper                                      20238.7100   18990.1500    1248.5600
Print.                                         0.0000       0.0000       0.0000
Prima.                                     18692.1000   18268.9300     423.1700
Metal                                        562.0840     537.7122      24.3718
Machinery                                      0.0000       0.0000       0.0000
Transportation                               793.9701     768.0214      25.9487
Electrical P.                                  0.0000       0.0000       0.0000
Non-Metal.                                  2976.4110    2613.6570     362.7540
Petroleum P.                               66889.3400   63136.1600    3753.1800
Chemical P.                                39203.5000   38326.8900     876.6100
Other                                        795.8998     684.0262     111.8736
Construction                                   0.0000       0.0000       0.0000
Utilities                               4309724.0000 4267122.0000   42602.0000
 Use TAB to move right a column, Shift-TAB moves left, press ESC to exit screen
```

```
                         WATER COEFFICIENTS BY INDUSTRY
                                           Intake       Discharge    Difference
Trade                                   0.0                 0.0000       0.0000
Services                                       0.0000       0.0000       0.0000
Imputed Rent                                   0.0000       0.0000       0.0000









 Use TAB to move right a column, Shift-TAB moves left, press ESC to exit screen
```

```
                          AIR COEFFICIENTS BY INDUSTRY
                                      Sulphur Oxide Nitrogen Oxide Volatile O.
Agriculture                            0.0000             0.0000       0.0000
Forestry                                     0.0000       0.0000       0.0000
Fishing                                      0.0069       0.0038       0.0001
Mining                                       0.0000       0.0051       0.0002
Food                                         0.0102       0.0183       0.0050
Textile                                      0.0237       0.0311       0.0360
Knitting                                     0.0000       0.0000       0.0000
Wood                                         0.0000       0.0004       0.0002
Furniture                                    0.0000       0.0000       0.0000
Paper                                        0.0624       0.0435       0.0036
Print.                                       0.0004       0.0010       0.0000
Prima.                                       0.1981       0.1575       0.0425
Metal                                        0.0130       0.0093       0.0042
Machinery                                    0.0013       0.0026       0.0086
Transportation                               0.0093       0.0072       0.0004
Electrical P.                                0.0017       0.0025       0.0000
Non-Metal.                                   0.6693       0.4534       0.0087
Petroleum P.                                 4.2980       1.3205       0.3178
Chemical P.                                  0.1929       0.3788       0.0146
Other                                        0.0029       0.0068       0.0057
Construction                                 0.0000       0.0000       0.0000
Utilities                                    1.1297       0.3150       0.0023
 Use TAB to move right a column, Shift-TAB moves left, press ESC to exit scree

                          AIR COEFFICIENTS BY INDUSTRY
                                      Sulphur Oxide Nitrogen Oxide Volatile O.
Trade                                  0.0001             0.0001       0.0000
Services                                     0.0007       0.0005       0.0001
Imputed Rent                                 0.0028       0.0030       0.0005














 Use TAB to move right a column, Shift-TAB moves left, press ESC to exit scree
```

```
                          WASTE COEFFICIENTS BY INDUSTRY

Agriculture                              2.3700
Forestry                                       2.3700
Fishing                                        2.3700
Mining                                         0.0000
Food                                          10.9700
Textile                                        1.2700
Knitting                                       1.2700
Wood                                           2.5400
Furniture                                      5.8500
Paper                                          4.1000
Print.                                         1.5600
Prima.                                         5.4400
Metal                                          4.9400
Machinery                                      1.7300
Transportation                                 3.7900
Electrical P.                                  3.2700
Non-Metal.                                     5.6500
Petroleum P.                                   0.0000
Chemical P.                                    7.1600
Other                                          4.3700
Construction                                  10.9600
Utilities                                      1.8400
                                                         press ESC to exit screen
```

```
                          WASTE COEFFICIENTS BY INDUSTRY

Trade                                    1.7800
Services                                       3.4500
Imputed Rent                                   1.0200




                                                         press ESC to exit screen
```

Base Case
Results By Sector

Base Case
Ontario Economy 1990

Date : 10/07/1992

Provincial Impact

(Millions)

	Direct	Indirect & Induced	Total
Gross Domestic Product	204087.03	73290.88	277377.91
Gross Sales	167030.00	292169.64	459199.64
Labour Income	42018.49	110046.68	152065.17
Employment (Person Years)	1499409	3091084	4590492

```
Date : 10/07/1992
                              Employment by Industry
                              ----------------------
                                   (Person Years)

 Agriculture          197442.29    Forestry                12548.66
 Fishing                1923.11    Mining                  32320.90
 Food                 106658.66    Textile                 53931.26
 Knitting              67302.26    Wood                    41987.24
 Furniture             35117.74    Paper                   63365.13
 Print.                82621.29    Prima.                  87124.16
 Metal                117527.31    Machinery              127322.17
 Transportation       230376.88    Electrical P.          116068.19
 Non-Metal.            29513.16    Petroleum P.            16392.85
 Chemical P.           61989.85    Other                  166532.35
 Construction         264672.49    Utilities              368218.29
 Trade               1153746.24    Services              1025448.93
 Imputed Rent              0.00    Initial Emp.           130341.10
 TOTAL               4590492.49
```

Base Case
Ontario Economy 1990

Date : 10/07/1992

Taxes

(Millions)

	Federal	Provincial	Local	Total
Personal Tax	17917.42	8431.73	0.00	26349.15
Indirect Business Tax	0.00	11297.32	0.00	11297.32
Tariffs	4720.65	0.00	0.00	4720.65
Corporate Profit Tax	6368.84	3136.89	0.00	9505.73
Property & Business Tax	0.00	0.00	9779.77	9779.77
Goods & Services Tax	16583.31	0.00	0.00	16583.31
Total Taxes	45590.22	22865.94	9779.77	78235.93

Base Case
Ontario Economy 1990

Date : 10/07/1992

Imports

(Millions)

Imports from Other Provinces	45415.37
Imports from Outside Canada	54974.42
Total Imports	100389.79

Date : 10/07/1992

Base Case
Ontario Economy 1990

Industry Output

(Millions)

Agriculture	7743.21	Forestry	998.08
Fishing	90.77	Mining	2589.63
Food	19641.81	Textile	5384.87
Knitting	2860.80	Wood	2463.31
Furniture	2881.85	Paper	9613.82
Print.	7711.61	Prima.	15662.51
Metal	13451.51	Machinery	16562.95
Transportation	56048.81	Electrical P.	11818.27
Non-Metal.	4967.23	Petroleum P.	13279.91
Chemical P.	15153.32	Other	15846.77
Construction	29528.26	Utilities	39672.05
Trade	73447.90	Travel & Accom.	73919.24
Housing	17861.16	TOTAL	459199.64

Base Case
Ontario Economy 1990

Date : 10/07/1992

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Agriculture	0	0	0
Forestry	0	0	0
Fishing	0	0	0
Mining	159959	182275	-22317
Food	259856	232830	27026
Textile	363745	360362	3383
Knitting	0	0	0
Wood	30444	28417	2027
Furniture	0	0	0
Paper	1282428	1203313	79115
Print.	0	0	0
Prima.	1628534	1591665	36868
Metal	66060	63196	2864
Machinery	0	0	0
Transportation	182912	176934	5978
TOTALS	1594640234	1578673250	15966891

Base Case
Ontario Economy 1990

Date : 10/07/1992

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Print.	0	0	0
Prima.	1628534	1591665	36868
Metal	66060	63196	2864
Machinery	0	0	0
Transportation	182912	176934	5978
Electrical P.	0	0	0
Non-Metal.	87843	77137	10706
Petroleum P.	1096507	1034981	61525
Chemical P.	2430219	2375878	54341
Other	132543	113912	18631
Construction	0	0	0
Utilities	1586919184	1571232348	15686743
Trade	0	0	0
Services	0	0	0
Imputed Rent	0	0	0
TOTALS	1594640234	1578673250	15966891

Base Case
Ontario Economy 1990

Date : 10/07/1992

Air Emissions (tonnes)

	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Agriculture	0.02	3.64	0.28
Forestry	0.00	0.00	0.00
Fishing	13.22	7.37	0.11
Mining	1.35	166.20	7.54
Food	1082.76	1953.11	532.68
Textile	1277.98	1676.08	1943.95
Knitting	0.00	0.00	0.00
Wood	0.74	15.01	7.90
Furniture	0.00	0.00	0.00
Paper	3954.31	2754.58	227.42
Print.	31.63	81.73	1.30
Prima.	17261.62	13718.73	3703.20
Metal	1528.34	1089.33	488.77
Machinery	164.52	328.14	1096.24
Transportation	2135.82	1657.69	97.68
TOTALS	547158.12	199959.66	16349.50

Base Case
Ontario Economy 1990

Date : 10/07/1992

Air Emissions (tonnes)

	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Print.	31.63	81.73	1.30
Prima.	17261.62	13718.73	3703.20
Metal	1528.34	1089.33	488.77
Machinery	164.52	328.14	1096.24
Transportation	2135.82	1657.69	97.68
Electrical P.	200.35	288.15	5.56
Non-Metal.	19752.44	13380.22	257.15
Petroleum P.	70456.96	21646.85	5210.12
Chemical P.	11960.16	23480.11	907.97
Other	482.70	1136.68	948.64
Construction	0.00	0.00	0.00
Utilities	415972.84	115975.43	849.73
Trade	115.99	82.21	1.43
Services	764.38	518.41	61.82
Imputed Rent	0.00	0.00	0.00
TOTALS	547158.12	199959.66	16349.50

Base Case
Ontario Economy 1990

Date : 10/07/1992

Energy Used (terajoules)

	Coal	Crude Oil	Natural Gas
Agriculture	9933.07	0.00	12584.88
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	14474.18	0.00	17973.01
Food	9627.35	0.00	43762.02
Textile	2529.62	0.00	11498.61
Knitting	1623.52	0.00	7379.86
Wood	1883.94	0.00	8563.65
Furniture	1260.15	0.00	5728.13
Paper	30322.68	0.00	83443.25
Print.	2975.81	0.00	13526.81
Prima.	271871.78	0.00	94691.66
Metal	6385.79	0.00	29027.23
Machinery	7170.61	0.00	32594.69
Transportation	22453.09	0.00	102062.64
TOTALS	536382.49	1818309.63	898272.12

Base Case
Ontario Economy 1990

Date : 10/07/1992

Energy Used (terajoules)

	Coal	Crude Oil	Natural Gas
Print.	2975.81	0.00	13526.81
Prima.	271871.78	0.00	94691.66
Metal	6385.79	0.00	29027.23
Machinery	7170.61	0.00	32594.69
Transportation	22453.09	0.00	102062.64
Electrical P.	6051.14	0.00	27506.05
Non-Metal.	11914.77	0.00	9386.21
Petroleum P.	7714.07	1818309.63	14776.35
Chemical P.	22852.16	0.00	129209.06
Other	7767.23	0.00	35306.66
Construction	0.00	0.00	0.00
Utilities	1848.41	0.00	242.48
Trade	47708.48	0.00	109154.20
Services	48014.65	0.00	109854.68
Imputed Rent	0.00	0.00	0.00
TOTALS	536382.49	1818309.63	898272.12

Base Case
1990

Date : 12/17/1992

Waste Generated (tonnes)

	ONP	Fine Paper	Boxboard
Agriculture	14974.02	31351.86	29012.17
Forestry	951.69	1992.60	1843.90
Fishing	145.85	305.37	282.58
Mining	0.00	0.00	0.00
Food	37441.46	78393.05	72542.82
Textile	2191.77	4589.01	4246.55
Knitting	2735.16	5726.75	5299.38
Wood	3412.72	7145.39	6612.15
Furniture	6574.04	13764.40	12737.20
Paper	8313.50	17406.40	16107.41
Print.	4124.46	8635.58	7991.13
Prima.	15166.57	31755.02	29385.24
Metal	18578.72	38899.19	35996.26
Machinery	7048.56	14757.91	13656.58
Transportation	27940.11	58499.60	54133.96
TOTALS	498004.55	1042697.03	964883.82

Base Case
1990

Date : 12/17/1992

Waste Generated (tonnes)

	OCC	Mixed Paper	Magazines
Agriculture	38370.94	7019.07	11230.52
Forestry	2438.71	446.10	713.77
Fishing	373.74	68.37	109.39
Mining	0.00	0.00	0.00
Food	95943.73	17550.68	28081.09
Textile	5616.40	1027.39	1643.82
Knitting	7008.86	1282.11	2051.37
Wood	8745.10	1599.71	2559.54
Furniture	16845.98	3081.58	4930.53
Paper	21303.36	3896.96	6235.13
Print.	10568.92	1933.34	3093.34
Prima.	38864.35	7109.33	11374.93
Metal	47607.96	8708.77	13934.04
Machinery	18061.92	3304.01	5286.42
Transportation	71596.53	13096.93	20955.08
TOTALS	1276136.67	233439.63	373503.41

Base Case
1990

Date : 12/17/1992

Waste Generated (tonnes)

	Tel. Books	Glass Cont.	Plastic
Agriculture	467.94	5147.32	8890.83
Forestry	29.74	327.14	565.07
Fishing	4.56	50.14	86.60
Mining	0.00	0.00	0.00
Food	1170.05	12870.50	22230.86
Textile	68.49	753.42	1301.36
Knitting	85.47	940.21	1624.00
Wood	106.65	1173.12	2026.30
Furniture	205.44	2259.83	3903.34
Paper	259.80	2857.77	4936.14
Print.	128.89	1417.78	2448.90
Prima.	473.96	5213.51	9005.15
Metal	580.58	6386.43	11031.11
Machinery	220.27	2422.94	4185.08
Transportation	873.13	9604.41	16589.44
TOTALS	15562.64	171189.07	295690.20

```
Base Case                                                        Date : 12/17/1992
1990

                              Waste Generated (tonnes)
                              -------------------------
                                    Alumin. Cans      Tinplate     Used Tires

    Agriculture                          1403.81       2339.69        7487.01
    Forestry                               89.22        148.70         475.85
    Fishing                                13.67         22.79          72.92
    Mining                                  0.00          0.00           0.00
    Food                                 3510.14       5850.23       18720.73
    Textile                               205.48        342.46        1095.88
    Knitting                              256.42        427.37        1367.58
    Wood                                  319.94        533.24        1706.36
    Furniture                             616.32       1027.19        3287.02
    Paper                                 779.39       1298.99        4156.75
    Print.                                386.67        644.45        2062.23
    Prima.                               1421.87       2369.78        7583.29
    Metal                                1741.75       2902.92        9289.36
    Machinery                             660.80       1101.34        3524.28
    Transportation                       2619.39       4365.64       13970.05

    TOTALS                              46687.93      77813.21      249002.28
```

Base Case
1990

Date : 12/17/1992

Waste Generated (tonnes)

	Yard Waste	Food Waste	Wood Waste
Agriculture	9826.70	42582.38	125875.39
Forestry	624.55	2706.37	8000.15
Fishing	95.71	414.76	1226.04
Mining	0.00	0.00	0.00
Food	24570.95	106474.14	314742.23
Textile	1438.35	6232.84	18424.54
Knitting	1794.95	7778.12	22992.47
Wood	2239.60	9704.93	28688.20
Furniture	4314.21	18694.93	55263.03
Paper	5455.74	23641.53	69885.40
Print.	2706.67	11728.92	34671.20
Prima.	9953.06	43129.95	127494.02
Metal	12192.28	52833.23	156177.34
Machinery	4625.61	20044.33	59251.92
Transportation	18335.70	79454.68	234871.53
TOTALS	326815.49	1416200.45	4186350.78

Base Case
1990

Date : 12/17/1992

	Waste Generated (tonnes)		
	Demol. Waste	Diapers	Foundry Sand
Agriculture	11230.52	467.94	30883.92
Forestry	713.77	29.74	1962.86
Fishing	109.39	4.56	300.81
Mining	0.00	0.00	0.00
Food	28081.09	1170.05	77223.00
Textile	1643.82	68.49	4520.52
Knitting	2051.37	85.47	5641.28
Wood	2559.54	106.65	7038.74
Furniture	4930.53	205.44	13558.96
Paper	6235.13	259.80	17146.60
Print.	3093.34	128.89	8506.69
Prima.	11374.93	473.96	31281.06
Metal	13934.04	580.58	38318.60
Machinery	5286.42	220.27	14537.65
Transportation	20955.08	873.13	57626.47
TOTALS	373503.41	15562.64	1027134.39

Base Case
1990

Date : 12/17/1992

	Waste Generated (tonnes)		
	Foundry Sand	Other	TOTAL
Agriculture	30883.92	88440.33	467002.36
Forestry	1962.86	5620.92	29680.84
Fishing	300.81	861.42	4548.65
Mining	0.00	0.00	0.00
Food	77223.00	221138.59	1167705.38
Textile	4520.52	12945.12	68355.71
Knitting	5641.28	16154.56	85302.92
Wood	7038.74	20156.40	106434.31
Furniture	13558.96	38827.93	205027.89
Paper	17146.60	49101.64	259277.42
Print.	8506.69	24360.06	128631.44
Prima.	31281.06	89577.58	473007.55
Metal	38318.60	109730.54	579423.72
Machinery	14537.65	41630.53	219826.82
Transportation	57626.47	165021.26	871382.12
TOTALS	1027134.39	2941339.39	15531517.01

Base Case
Ontario Economy 1990

Date : 10/07/1992

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Durham (Oshawa SA)	22982660	22752307	230352
York	75712916	74961896	751016
Toronto	517277918	512108585	5169303
Peel	179408211	177625778	1782423
Halton	58354077	57774062	580012
TOTALS	853735782	845222628	8513105

Base Case
Ontario Economy 1990

Date : 10/07/1992

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Dufferin	2292584	2269676	22908
Wellington	9863516	9763189	100326
Bruce	4161106	4119746	41360
Grey	5272120	5219683	52436
Simcoe	16785263	16618046	167216
Muskoka	2811974	2784003	27971
Haliburton	819131	811038	8093
TOTALS	42005694	41585381	420311

Base Case
Ontario Economy 1990

Date : 10/07/1992

Air Emissions (tonnes)

	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Durham (Oshawa SA)	7695.97	3009.69	150.31
York	21083.07	6714.09	251.10
Toronto	162843.47	55497.96	3473.64
Peel	50320.58	16365.02	613.26
Halton	16857.76	5488.23	214.71
TOTALS	258800.84	87074.99	4703.02

Base Case
Ontario Economy 1990

Date : 10/07/1992

Air Emissions (tonnes)

	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Dufferin	767.18	332.98	24.74
Wellington	3601.73	1736.80	224.21
Bruce	1162.24	399.53	30.20
Grey	1735.50	644.87	36.59
Simcoe	4683.77	1700.00	196.16
Muskoka	793.75	260.69	17.12
Haliburton	215.08	60.43	0.56
TOTALS	12959.25	5135.28	529.59

Base Case
Results By Region

```
 Impact in Eastern Ontario

Year of Expenditure: 1991
Base Case

                 Demand for Water (thousands of cubic meters)

                                        Intake      Discharge     Net Usage
Stormont, Dundas, Glen                 7296530        7222276         74254
Prescott & Russell                     4064012        4023397         40615
Ottawa-Carleton RM                   144933933      143499642       1434282
Leeds & Grenville                      6043001        5981104         61896
Lanark                                 3527891        3492757         35134
Frontenac                            128833355      127559153       1274195
Lennox & Addington                     2432550        2408189         24360
Hastings (Trenton SA)                  7689589        7612514         77075
Prince Edward (Belleville SA)          1611100        1593097         18004
Northumberland (Cobourg SA)            4773447        4725335         48111
Peterborough                           7424865        7350097         74767
Victoria                               3692103        3655486         36617
Renfrew                                6326485        6261293         65192
___________________________________________________________________________
Totals                               328648862      325384341       3264502


 Impact in Central Ontario

Year of Expenditure: 1991
Base Case

                 Demand for Water (thousands of cubic meters)

                                        Intake      Discharge     Net Usage
Dufferin                               2292584        2269676         22908
Wellington                             9863516        9763189        100326
Bruce                                  4161106        4119746         41360
Grey                                   5272120        5219683         52436
Simcoe                                16785263       16618046        167216
Muskoka                                2811974        2784003         27971
Haliburton                              819131         811038          8093
___________________________________________________________________________
Totals                                42005694       41585381        420311
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case

                   Demand for Water (thousands of cubic meters)

                                       Intake      Discharge      Net Usage
Hamilton                             61745662       61119034         626625
St. Cath-Niag                        12497398       12366841         130556
Haldiman-Norfolk                      6559066        6487632          71434
Brant                                 7540436        7462895          77541
Waterloo                             60633722       60029669         604049
Perth                                 4701894        4654512          47381
Oxford                                6010636        5950054          60581
Elgin                                 4950479        4900467          50012
Kent                                  7529442        7453492          75949
Essex                                49750907       49255381         495523
Lambton                               6758115        6649356         108759
Middlesex                            51489768       50973375         516390
Huron                                 3932475        3893518          38957
___________________________________________________________________________

Totals                              284099999      281196226        2903757


 Impact in Northeastern Ontario

Year of Expenditure: 1991
Base Case

                   Demand for Water (thousands of cubic meters)

                                       Intake      Discharge      Net Usage
Nipissing                             5596387        5540488          55899
Parry Sound                           2398897        2375166          23731
Manitoulin                             702347         695489           6857
Sudbury D                             3214343        3180754          33589
Sudbury RM                           16057164       15902932         154231
Timiskaming                           2821289        2794569          26719
Cochrane D                            6650769        6582329          68440
Algoma                                3802022        3764689          37333
___________________________________________________________________________

Totals                               41243217       40836416         406799
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Base Case


                  Demand for Water (thousands of cubic meters)

                                      Intake       Discharge      Net Usage
Thunder Bay                         39541575        39139757         401815
Rainy River D                        1485463         1470813          14650
Kenora D                             3879620         3837667          41952
------------------------------------------------------------------------------
Totals                              44906658        44448237         458418



 Impact in Greater Toronto Area

Year of Expenditure: 1991
Base Case


                  Demand for Water (thousands of cubic meters)

                                      Intake       Discharge      Net Usage
Durham (Oshawa SA)                  22982660        22752307         230352
York                                75712916        74961896         751016
Toronto                            517277918       512108585        5169303
Peel                               179408211       177625778        1782423
Halton                              58354077        57774062         580012
------------------------------------------------------------------------------
Totals                             853735782       845222628        8513105
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Base Case


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Stormont, Dundas, Glen                  2514           1383              247
Prescott & Russell                      1665            772               89
Ottawa-Carleton RM                     38668          11452              176
Leeds & Grenville                       2398           1561              240
Lanark                                  1038            421               38
Frontenac                              34196           9834              320
Lennox & Addington                       871            407              157
Hastings (Trenton SA)                   2175            742               51
Prince Edward (Belleville SA)           3728           2402              103
Northumberland (Cobourg SA)             1646            720               83
Peterborough                            2507           1111              122
Victoria                                1146            405               19
Renfrew                                 2007            778               52
____________________________________________________________________________

Totals                                 94560          31989             1696


 Impact in Central Ontario

Year of Expenditure: 1991
Base Case


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Dufferin                                 767            333               25
Wellington                              3602           1737              224
Bruce                                   1162            400               30
Grey                                    1736            645               37
Simcoe                                  4685           1701              196
Muskoka                                  794            261               17
Haliburton                               215             60                1
____________________________________________________________________________

Totals                                 12962           5137              530
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case

                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Hamilton                               28187          13677             2032
St. Cath-Niag                           9112           4648              601
Haldiman-Norfolk                        4153           2461              393
Brant                                   3756           1712              273
Waterloo                               17386           6022              530
Perth                                   1375            528              102
Oxford                                  2726           1316              162
Elgin                                   1609            650               71
Kent                                    3210           1466               84
Essex                                  14983           5446              310
Lambton                                51090          21577             3685
Middlesex                              15239           5723              373
Huron                                   1124            398               26
___________________________________________________________________________
Totals                                153949          65623             8641


 Impact in Northeastern Ontario

Year of Expenditure: 1991
Base Case

                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Nipissing                               1664            682               64
Parry Sound                              635            182                6
Manitoulin                               185             52                1
Sudbury D                                968            335               19
Sudbury RM                              4624           1750               83
Timiskaming                              772            249               12
Cochrane D                              2030            729               23
Algoma                                  3198           2067              461
___________________________________________________________________________
Totals                                 14075           6046              668
```

```
******************************* LINK: Ontario 2.0 *****************************
********************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Base Case

                                      Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide    Volatile Org C
Thunder Bay                            11099           3453              72
Rainy River D                            391            110               1
Kenora D                                1366            557              43
-----------------------------------------------------------------------------
Totals                                 12855           4120             116



 Impact in Greater Toronto Area

Year of Expenditure: 1991
Base Case


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide    Volatile Org C
Durham (Oshawa SA)                      7697           3011             150
York                                   21088           6717             251
Toronto                               162879          55522            3476
Peel                                   50328          16370             614
Halton                                 16861           5491             215
-----------------------------------------------------------------------------
Totals                                258853          87110            4707
```

```
****************************** LINK: Ontario 2.0 ******************************
*********************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Base Case


                              Energy Used (terajoules)

                                     Coal        Crude Oil     Natural Gas
Stormont, Dundas, Glen               4997                0           12397
Prescott & Russell                   3777                0            6229
Ottawa-Carleton RM                  44042              100          124867
Leeds & Grenville                    8027              453           14659
Lanark                               2139                0            5173
Frontenac                            7448                0           15827
Lennox & Addington                   1260                0            3865
Hastings (Trenton SA)                4285                0           10796
Prince Edward (Belleville SA)        4207                0            4363
Northumberland (Cobourg SA)          4562             1238            6713
Peterborough                         5613                0            9007
Victoria                             1758                0            2716
Renfrew                              6352                0           13177
--------------------------------------------------------------------------
Totals                              98466             1791          229789


                              Electricity  Nuclear Steam           TOTAL
Stormont, Dundas, Glen               2782              907           21083
Prescott & Russell                   1736              222           11964
Ottawa-Carleton RM                  36415             3016          208440
Leeds & Grenville                    3115             1218           27472
Lanark                               1337              245            8893
Frontenac                            4503              289           28067
Lennox & Addington                    968               81            6175
Hastings (Trenton SA)                2963              269           18313
Prince Edward (Belleville SA)        1003               72            9645
Northumberland (Cobourg SA)          1643              294           14451
Peterborough                         2158              422           17200
Victoria                              803               93            5369
Renfrew                              3588              302           23418
--------------------------------------------------------------------------
Totals                              63014             7430          400490
```

```
****************************** LINK: Ontario 2.0 *****************************
******************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Base Case

                            Energy Used (terajoules)

                                           Coal      Crude Oil    Natural Gas
Dufferin                                 1094              0           2284
Wellington                               7476           6386          16593
Bruce                                    1476              0           4163
Grey                                     2300             62           4855
Simcoe                                   6616              0          20970
Muskoka                                  1029              0           2896
Haliburton                                207              0            592
-----------------------------------------------------------------------------
Totals                                  20198           6448          52353


                                    Electricity  Nuclear Steam          TOTAL
Dufferin                                  606            158           4141
Wellington                               3793           1040          35287
Bruce                                    1204            281           7123
Grey                                     1371            178           8765
Simcoe                                   5403            818          33807
Muskoka                                   724             64           4714
Haliburton                                172             11            982
-----------------------------------------------------------------------------
Totals                                  13272           2549          94820
```

```
****************************** LINK: Ontario 2.0 ******************************
**************************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case


                              Energy Used (terajoules)

                                           Coal      Crude Oil    Natural Gas
Hamilton                                 122559        71041         81814
St. Cath-Niag                             28146        66783         40534
Haldiman-Norfolk                          27162            0         20180
Brant                                      4506        29224         12004
Waterloo                                  14217         4329         35521
Perth                                      2333            0          6556
Oxford                                     5421          438          8052
Elgin                                      4709            0         11475
Kent                                       6393            0         11398
Essex                                     18757         1082         42958
Lambton                                   14117      1186094         52842
Middlesex                                 22907            0         40154
Huron                                      2408            0          4562
-------------------------------------------------------------------------------
Totals                                   273635      1358992        368051


                                    Electricity  Nuclear Steam         TOTAL
Hamilton                                  18797         2949        297160
St. Cath-Niag                             10092         1795        147350
Haldiman-Norfolk                           4955          527         52824
Brant                                      2704          844         49282
Waterloo                                   8437         1418         63922
Perth                                      1726          356         10971
Oxford                                     2151          368         16429
Elgin                                      2459          360         19003
Kent                                       2783          363         20936
Essex                                      9456         1471         73725
Lambton                                   10938        10934       1274925
Middlesex                                 10236         1955         75252
Huron                                      1523          361          8854
-------------------------------------------------------------------------------
Totals                                    86257        23698       2110633
```

```
****************************** LINK: Ontario 2.0 ****************************
*****************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Base Case

                              Energy Used (terajoules)

                                          Coal       Crude Oil    Natural Gas
Nipissing                               3338               0           8361
Parry Sound                              693               0           1897
Manitoulin                               241               0            577
Sudbury D                               1874               0           4817
Sudbury RM                             10579               0          19439
Timiskaming                             1869               0           3222
Cochrane D                              4633               0          11512
Algoma                                 37618             136          21071
-----------------------------------------------------------------------------
Totals                                 60845             136          70895


                                   Electricity   Nuclear Steam          TOTAL
Nipissing                               2226             373          14298
Parry Sound                              550              37           3177
Manitoulin                               191              15           1025
Sudbury D                               1375              33           8099
Sudbury RM                              6157             711          36885
Timiskaming                             1060              53           6204
Cochrane D                              3343             132          19619
Algoma                                  5649             121          64596
-----------------------------------------------------------------------------
Totals                                 20552            1474         153903
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Base Case

                             Energy Used (terajoules)

                                            Coal      Crude Oil    Natural Gas
Thunder Bay                                 9966              0          26830
Rainy River D                                492              0           1340
Kenora D                                    5516              0          11072
------------------------------------------------------------------------------
Totals                                     15973              0          39243


                                     Electricity  Nuclear Steam          TOTAL
Thunder Bay                                 7528            241          44565
Rainy River D                                416             31           2279
Kenora D                                    3093             81          19761
------------------------------------------------------------------------------
Totals                                     11038            352          66605



 Impact in Greater Toronto Area

Year of Expenditure: 1991
Base Case

                             Energy Used (terajoules)

                                            Coal      Crude Oil    Natural Gas
Durham (Oshawa SA)                         15873           3044          48213
York                                       15880            760          36801
Toronto                                   113410         421091         299630
Peel                                       26440          17765          71581
Halton                                     13883           8279          38457
------------------------------------------------------------------------------
Totals                                    185486         450939         494682


                                     Electricity  Nuclear Steam          TOTAL
Durham (Oshawa SA)                         10092           1092          78314
York                                       10227           1191          64860
Toronto                                    77364          12900         924395
Peel                                       18380           3339         137506
Halton                                      9614           1016          71249
------------------------------------------------------------------------------
Totals                                    125677          19539        1276323
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Eastern Ontario
Year of Expenditure: 1991
Base Case
                            Waste Generated (tonnes)

                                      ONP     Fine Paper         Boxboard
Stormont, Dundas, Glen               5419          11346            10499
Prescott & Russell                   2269           4750             4396
Ottawa-Carleton RM                  29287          61319            56743
Leeds & Grenville                    4340           9087             8409
Lanark                               1729           3620             3350
Frontenac                            7301          15286            14146
Lennox & Addington                   1336           2797             2588
Hastings (Trenton SA)                3309           6929             6412
Prince Edward (Belleville SA)        2266           4745             4391
Northumberland (Cobourg SA)          2870           6009             5560
Peterborough                         3834           8028             7429
Victoria                             1636           3426             3170
Renfrew                              2750           5758             5328
______________________________________________________________________________

Totals                              68346         143099           132420

                                      OCC    Mixed Paper        Magazines
Stormont, Dundas, Glen              13886           2540             4064
Prescott & Russell                   5814           1063             1702
Ottawa-Carleton RM                  75047          13728            21965
Leeds & Grenville                   11122           2034             3255
Lanark                               4430            810             1297
Frontenac                           18709           3422             5476
Lennox & Addington                   3423            626             1002
Hastings (Trenton SA)                8480           1551             2482
Prince Edward (Belleville SA)        5807           1062             1700
Northumberland (Cobourg SA)          7354           1345             2152
Peterborough                         9825           1797             2876
Victoria                             4193            767             1227
Renfrew                              7047           1289             2063
______________________________________________________________________________

Totals                             175136          32037            51259

                               Tel. Books    Glass Cont.          Plastic
Stormont, Dundas, Glen                169           1863             3217
Prescott & Russell                     71            780             1347
Ottawa-Carleton RM                    915          10067            17389
Leeds & Grenville                     136           1492             2577
Lanark                                 54            594             1027
Frontenac                             228           2510             4335
Lennox & Addington                     42            459              793
Hastings (Trenton SA)                 103           1138             1965
Prince Edward (Belleville SA)          71            779             1345
Northumberland (Cobourg SA)            90            986             1704
Peterborough                          120           1318             2276
Victoria                               51            562              972
Renfrew                                86            945             1633
______________________________________________________________________________

Totals                               2136          23494            40580
```

```
******************************* LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Base Case
                             Waste Generated (tonnes)

                              Alumin. Cans        Tinplate      Used Tires
Stormont, Dundas, Glen                 508             847            2709
Prescott & Russell                     213             354            1134
Ottawa-Carleton RM                    2746            4576           14643
Leeds & Grenville                      407             678            2170
Lanark                                 162             270             864
Frontenac                              684            1141            3650
Lennox & Addington                     125             209             668
Hastings (Trenton SA)                  310             517            1655
Prince Edward (Belleville SA)          212             354            1133
Northumberland (Cobourg SA)            269             448            1435
Peterborough                           359             599            1917
Victoria                               153             256             818
Renfrew                                258             430            1375
------------------------------------------------------------------------------
Totals                                6407           10679           34173

                                Yard Waste      Food Waste      Wood Waste
Stormont, Dundas, Glen                3556           15410           45552
Prescott & Russell                    1489            6452           19072
Ottawa-Carleton RM                   19219           83284          246190
Leeds & Grenville                     2848           12343           36485
Lanark                                1135            4917           14534
Frontenac                             4791           20762           61374
Lennox & Addington                     877            3799           11230
Hastings (Trenton SA)                 2172            9411           27819
Prince Edward (Belleville SA)         1487            6444           19049
Northumberland (Cobourg SA)           1883            8161           24124
Peterborough                          2516           10903           32230
Victoria                              1074            4653           13755
Renfrew                               1805            7820           23117
------------------------------------------------------------------------------
Totals                               44852          194358          574532

                              Demol. Waste         Diapers    Foundry Sand
Stormont, Dundas, Glen                4064             169           11176
Prescott & Russell                    1702              71            4679
Ottawa-Carleton RM                   21965             915           60403
Leeds & Grenville                     3255             136            8952
Lanark                                1297              54            3566
Frontenac                             5476             228           15058
Lennox & Addington                    1002              42            2755
Hastings (Trenton SA)                 2482             103            6826
Prince Edward (Belleville SA)         1700              71            4674
Northumberland (Cobourg SA)           2152              90            5919
Peterborough                          2876             120            7908
Victoria                              1227              51            3375
Renfrew                               2063              86            5672
------------------------------------------------------------------------------
Totals                               51259            2136          140963
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Base Case

                             Waste Generated (tonnes)

                                     Other           TOTAL
Stormont, Dundas, Glen               32005          169001
Prescott & Russell                   13400           70756
Ottawa-Carleton RM                  172974          913374
Leeds & Grenville                    25635          135362
Lanark                               10211           53920
Frontenac                            43121          227698
Lennox & Addington                    7890           41665
Hastings (Trenton SA)                19546          103211
Prince Edward (Belleville SA)        13384           70673
Northumberland (Cobourg SA)          16950           89502
Peterborough                         22645          119575
Victoria                              9664           51032
Renfrew                              16242           85766
-----------------------------------------------------------------------------
Totals                              403668         2131536
```

```
******************************* LINK: Ontario 2.0 *******************************
***********************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Base Case
                             Waste Generated (tonnes)

                                        ONP        Fine Paper           Boxboard
Dufferin                               1269              2657               2459
Wellington                             7387             15466              14311
Bruce                                  2732              5719               5293
Grey                                   2934              6143               5685
Simcoe                                 9311             19495              18040
Muskoka                                1655              3465               3207
Haliburton                              362               758                702
________________________________________________________________________________
Totals                                25649             53704              49696

                                        OCC       Mixed Paper          Magazines
Dufferin                               3252               595                952
Wellington                            18928              3462               5540
Bruce                                  7000              1280               2049
Grey                                   7518              1375               2200
Simcoe                                23860              4365               6983
Muskoka                                4241               776               1241
Haliburton                              928               170                272
________________________________________________________________________________
Totals                                65727             12023              19237

                                 Tel. Books       Glass Cont.            Plastic
Dufferin                                 40               436                754
Wellington                              231              2539               4386
Bruce                                    85               939               1622
Grey                                     92              1009               1742
Simcoe                                  291              3201               5528
Muskoka                                  52               569                983
Haliburton                               11               124                215
________________________________________________________________________________
Totals                                  802              8817              15229

                               Alumin. Cans          Tinplate         Used Tires
Dufferin                                119               198                635
Wellington                              692              1154               3693
Bruce                                   256               427               1366
Grey                                    275               458               1467
Simcoe                                  873              1455               4656
Muskoka                                 155               259                828
Haliburton                               34                57                181
________________________________________________________________________________
Totals                                 2405              4008              12825
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Base Case

                              Waste Generated (tonnes)

                                  Yard Waste       Food Waste       Wood Waste
Dufferin                                 833             3609            10669
Wellington                              4847            21005            62093
Bruce                                   1793             7768            22963
Grey                                    1925             8343            24664
Simcoe                                  6110            26478            78271
Muskoka                                 1086             4706            13913
Haliburton                               238             1030             3044
______________________________________________________________________________

Totals                                 16832            72941           215616


                                Demol. Waste         Diapers      Foundry Sand
Dufferin                                 952               40             2618
Wellington                              5540              231            15235
Bruce                                   2049               85             5634
Grey                                    2200               92             6051
Simcoe                                  6983              291            19204
Muskoka                                 1241               52             3413
Haliburton                               272               11              747
______________________________________________________________________________

Totals                                 19237              802            52902


                                       Other            TOTAL
Dufferin                                7496            39583
Wellington                             43627           230367
Bruce                                  16134            85193
Grey                                   17329            91503
Simcoe                                 54993           290388
Muskoka                                 9775            51616
Haliburton                              2139            11292
______________________________________________________________________________

Totals                                151492           799943
```

```
****************************** LINK: Ontario 2.0 *******************************
*********************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case
                             Waste Generated (tonnes)

                                        ONP     Fine Paper         Boxboard
Hamilton                              29243          61227            56658
St. Cath-Niag                         17859          37392            34601
Haldiman-Norfolk                       6011          12587            11647
Brant                                  4268           8936             8269
Waterloo                              21069          44112            40820
Perth                                  3986           8345             7723
Oxford                                 4155           8699             8050
Elgin                                  4358           9125             8444
Kent                                   5037          10545             9758
Essex                                 17741          37146            34374
Lambton                                8379          17543            16234
Middlesex                             17832          37337            34550
Huron                                  2788           5837             5401
_____________________________________________________________________________
Totals                               142725         298830           276529

                                        OCC    Mixed Paper        Magazines
Hamilton                              74934          13708            21932
St. Cath-Niag                         45763           8371            13394
Haldiman-Norfolk                      15404           2818             4509
Brant                                 10936           2000             3201
Waterloo                              53988           9876            15801
Perth                                 10214           1868             2989
Oxford                                10647           1948             3116
Elgin                                 11167           2043             3268
Kent                                  12906           2361             3777
Essex                                 45462           8316            13306
Lambton                               21471           3928             6284
Middlesex                             45695           8359            13374
Huron                                  7143           1307             2091
_____________________________________________________________________________
Totals                               365732          66902           107043

                                 Tel. Books    Glass Cont.          Plastic
Hamilton                                914          10052            17363
St. Cath-Niag                           558           6139            10604
Haldiman-Norfolk                        188           2066             3569
Brant                                   133           1467             2534
Waterloo                                658           7242            12509
Perth                                   125           1370             2367
Oxford                                  130           1428             2467
Elgin                                   136           1498             2588
Kent                                    157           1731             2991
Essex                                   554           6099            10534
Lambton                                 262           2880             4975
Middlesex                               557           6130            10588
Huron                                    87            958             1655
_____________________________________________________________________________
Totals                                 4460          49062            84743
```

```
****************************** LINK: Ontario 2.0 *****************************
*******************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case
                             Waste Generated (tonnes)

                               Alumin. Cans         Tinplate       Used Tires
Hamilton                               2742             4569            14621
St. Cath-Niag                          1674             2790             8929
Haldiman-Norfolk                        564              939             3006
Brant                                   400              667             2134
Waterloo                               1975             3292            10534
Perth                                   374              623             1993
Oxford                                  390              649             2077
Elgin                                   409              681             2179
Kent                                    472              787             2518
Essex                                  1663             2772             8871
Lambton                                 786             1309             4189
Middlesex                              1672             2786             8916
Huron                                   261              436             1394
-----------------------------------------------------------------------------
Totals                                13380            22301            71362

                                 Yard Waste       Food Waste       Wood Waste
Hamilton                              19191            83159           245821
St. Cath-Niag                         11720            50786           150125
Haldiman-Norfolk                       3945            17095            50534
Brant                                  2801            12136            35875
Waterloo                              13826            59914           177107
Perth                                  2616            11335            33506
Oxford                                 2727            11815            34927
Elgin                                  2860            12393            36634
Kent                                   3305            14323            42339
Essex                                 11643            50452           149139
Lambton                                5499            23828            70435
Middlesex                             11703            50711           149904
Huron                                  1829             7927            23433
-----------------------------------------------------------------------------
Totals                                93663           405873          1199779

                               Demol. Waste          Diapers     Foundry Sand
Hamilton                              21932              914            60313
St. Cath-Niag                         13394              558            36834
Haldiman-Norfolk                       4509              188            12399
Brant                                  3201              133             8802
Waterloo                              15801              658            43454
Perth                                  2989              125             8221
Oxford                                 3116              130             8569
Elgin                                  3268              136             8988
Kent                                   3777              157            10388
Essex                                 13306              554            36592
Lambton                                6284              262            17281
Middlesex                             13374              557            36779
Huron                                  2091               87             5749
-----------------------------------------------------------------------------
Totals                               107043             4460           294370
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case


                             Waste Generated (tonnes)

                                      Other            TOTAL
Hamilton                               172715          912007
St. Cath-Niag                          105478          556968
Haldiman-Norfolk                        35505          187483
Brant                                   25206          133099
Waterloo                               124436          657074
Perth                                   23541          124308
Oxford                                  24539          129579
Elgin                                   25739          135914
Kent                                    29748          157080
Essex                                  104785          553309
Lambton                                 49488          261317
Middlesex                              105323          556148
Huron                                   16464           86939
------------------------------------------------------------------------------
Totals                                 842967         4451225
```

```
******************************* LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Base Case
                              Waste Generated (tonnes)

                                       ONP       Fine Paper          Boxboard
Nipissing                             2090             4377              4050
Parry Sound                            957             2003              1854
Manitoulin                             213              447               413
Sudbury D                             1160             2430              2248
Sudbury RM                            5698            11930             11040
Timiskaming                           1181             2473              2289
Cochrane D                            2721             5698              5272
Algoma                                5376            11257             10417
-----------------------------------------------------------------------------
Totals                               19398            40614             37583

                                       OCC      Mixed Paper         Magazines
Nipissing                             5357              980              1568
Parry Sound                           2452              449               718
Manitoulin                             547              100               160
Sudbury D                             2974              544               870
Sudbury RM                           14601             2671              4273
Timiskaming                           3027              554               886
Cochrane D                            6973             1276              2041
Algoma                               13777             2520              4032
-----------------------------------------------------------------------------
Totals                               49707             9093             14548

                                Tel. Books      Glass Cont.           Plastic
Nipissing                               65              719              1241
Parry Sound                             30              329               568
Manitoulin                               7               73               127
Sudbury D                               36              399               689
Sudbury RM                             178             1959              3383
Timiskaming                             37              406               701
Cochrane D                              85              935              1616
Algoma                                 168             1848              3192
-----------------------------------------------------------------------------
Totals                                 606             6668             11517

                              Alumin. Cans         Tinplate        Used Tires
Nipissing                              196              327              1045
Parry Sound                             90              150               478
Manitoulin                              20               33               107
Sudbury D                              109              181               580
Sudbury RM                             534              890              2849
Timiskaming                            111              185               591
Cochrane D                             255              425              1361
Algoma                                 504              840              2688
-----------------------------------------------------------------------------
Totals                                1819             3031              9699
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Base Case

                             Waste Generated (tonnes)

                                Yard Waste       Food Waste       Wood Waste
Nipissing                               1372           5945           17573
Parry Sound                              628           2721            8043
Manitoulin                               140            607            1793
Sudbury D                                762           3300            9755
Sudbury RM                              3739          16203           47897
Timiskaming                              775           3359            9930
Cochrane D                              1786           7739           22875
Algoma                                  3528          15289           45195
___________________________________________________________________________
Totals                                 12730          55163          163063


                              Demol. Waste          Diapers     Foundry Sand
Nipissing                               1568             65            4312
Parry Sound                              718             30            1973
Manitoulin                               160              7             440
Sudbury D                                870             36            2393
Sudbury RM                              4273            178           11752
Timiskaming                              886             37            2436
Cochrane D                              2041             85            5613
Algoma                                  4032            168           11089
___________________________________________________________________________
Totals                                 14548            606           40008


                                     Other            TOTAL
Nipissing                              12347          65197
Parry Sound                             5651          29841
Manitoulin                              1260           6652
Sudbury D                               6854          36193
Sudbury RM                             33653         177701
Timiskaming                             6977          36842
Cochrane D                             16072          84869
Algoma                                 31754         167677
___________________________________________________________________________
Totals                                114568         604970
```

```
****************************** LINK: Ontario 2.0 *****************************
*****************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Base Case
                            Waste Generated (tonnes)

                                       ONP       Fine Paper          Boxboard
Thunder Bay                           6850          14342             13272
Rainy River D                          474            993               919
Kenora D                              1880           3936              3642
-----------------------------------------------------------------------------
Totals                                9204          19271             17833

                                       OCC      Mixed Paper         Magazines
Thunder Bay                          17553           3211              5138
Rainy River D                         1215            222               356
Kenora D                              4817            881              1410
-----------------------------------------------------------------------------
Totals                               23585           4314              6903

                                Tel. Books      Glass Cont.           Plastic
Thunder Bay                            214           2355              4067
Rainy River D                           15            163               281
Kenora D                                59            646              1116
-----------------------------------------------------------------------------
Totals                                 288           3164              5465

                              Alumin. Cans         Tinplate        Used Tires
Thunder Bay                            642           1070              3425
Rainy River D                           44             74               237
Kenora D                               176            294               940
-----------------------------------------------------------------------------
Totals                                 863           1438              4602

                                Yard Waste       Food Waste        Wood Waste
Thunder Bay                           4495          19480             57583
Rainy River D                          311           1348              3985
Kenora D                              1234           5346             15803
-----------------------------------------------------------------------------
Totals                                6040          26174             77372

                              Demol. Waste          Diapers      Foundry Sand
Thunder Bay                           5138            214             14128
Rainy River D                          356             15               978
Kenora D                              1410             59              3877
-----------------------------------------------------------------------------
Totals                                6903            288             18983

                                     Other            TOTAL
Thunder Bay                          40458         213636
Rainy River D                         2800          14785
Kenora D                             11103          58631
-----------------------------------------------------------------------------
Totals                               54362         287052
```

```
****************************** LINK: Ontario 2.0 ********************************
*********************************************************************************

 Impact in Greater Toronto Area

Year of Expenditure: 1991
Base Case

                             Waste Generated (tonnes)

                                         ONP       Fine Paper         Boxboard
Durham (Oshawa SA)                     16702            34970            32360
York                                   22050            46168            42722
Toronto                               154542           323571           299424
Peel                                   35940            75248            69633
Halton                                 17839            37351            34563
------------------------------------------------------------------------------
Totals                                247072           517308           478703

                                         OCC      Mixed Paper        Magazines
Durham (Oshawa SA)                     42799             7829            12527
York                                   56504            10336            16538
Toronto                               396013            72441           115906
Peel                                   92095            16847            26955
Halton                                 45713             8362            13379
------------------------------------------------------------------------------
Totals                                633123           115815           185304

                                  Tel. Books      Glass Cont.          Plastic
Durham (Oshawa SA)                       522             5741             9917
York                                     689             7580            13092
Toronto                                 4829            53124            91759
Peel                                    1123            12354            21339
Halton                                   557             6132            10592
------------------------------------------------------------------------------
Totals                                  7721            84931           146699

                                Alumin. Cans         Tinplate       Used Tires
Durham (Oshawa SA)                      1566             2610             8351
York                                    2067             3445            11025
Toronto                                14488            24147            77271
Peel                                    3369             5616            17970
Halton                                  1672             2787             8920
------------------------------------------------------------------------------
Totals                                 23163            38605           123536

                                  Yard Waste       Food Waste       Wood Waste
Durham (Oshawa SA)                     10961            47496           140401
York                                   14470            62705           185359
Toronto                               101418           439477          1299115
Peel                                   23585           102203           302117
Halton                                 11707            50730           149960
------------------------------------------------------------------------------
Totals                                162141           702612          2076952
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Greater Toronto Area

Year of Expenditure: 1991
Base Case

                           Waste Generated (tonnes)

                              Demol. Waste        Diapers     Foundry Sand
Durham (Oshawa SA)                   12527            522            34448
York                                 16538            689            45478
Toronto                             115906           4829           318742
Peel                                 26955           1123            74125
Halton                               13379            557            36793
__________________________________________________________________________
Totals                              185304           7721           509587


                                     Other          TOTAL
Durham (Oshawa SA)                   98646         520895
York                                130234         687689
Toronto                             912761        4819764
Peel                                212268        1120866
Halton                              105362         556357
__________________________________________________________________________
Totals                             1459271        7705570
```

```
****************************** LINK: Ontario 2.0 *******************************
********************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Base Case
                             Contaminants (tonnes)

                                    Ammonia-N      Oil & Grease   TSS
Stormont, Dundas, Glen                     77             62           1288
Prescott & Russell                         35             55            897
Ottawa-Carleton RM                         96             70           2068
Leeds & Grenville                         149            116           2630
Lanark                                     27             17            413
Frontenac                                  45             40            924
Lennox & Addington                          8              8            652
Hastings (Trenton SA)                      34             18           1349
Prince Edward (Belleville SA)              26            217           3551
Northumberland (Cobourg SA)                58             53            836
Peterborough                               86             74           1968
Victoria                                   17             21            276
Renfrew                                    88             41           5042
-----------------------------------------------------------------------------
Totals                                    746            791          21893

                                    Phosphorus     Cyanide        Phenolics
Stormont, Dundas, Glen                      8              3              3
Prescott & Russell                          2              2              1
Ottawa-Carleton RM                         14              3              4
Leeds & Grenville                          19              6              4
Lanark                                      2              1              2
Frontenac                                   3              3              2
Lennox & Addington                          4              0              0
Hastings (Trenton SA)                      10              1              1
Prince Edward (Belleville SA)               2              2              1
Northumberland (Cobourg SA)                 3              4              2
Peterborough                               11              4              2
Victoria                                    0              1              0
Renfrew                                    39              3              1
-----------------------------------------------------------------------------
Totals                                    117             33             23

                                    Copper         Lead           Zinc
Stormont, Dundas, Glen                      1              1             14
Prescott & Russell                          0              0              5
Ottawa-Carleton RM                          1              2             19
Leeds & Grenville                           1              2             17
Lanark                                      0              0              9
Frontenac                                   0              0             11
Lennox & Addington                          0              0              2
Hastings (Trenton SA)                       0              0              5
Prince Edward (Belleville SA)               0              0              5
Northumberland (Cobourg SA)                 0              1              8
Peterborough                                1              1             12
Victoria                                    0              0              2
Renfrew                                     0              0              9
-----------------------------------------------------------------------------
Totals                                      5              8            118
```

```
****************************** LINK: Ontario 2.0 *****************************
*****************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Base Case
                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Dufferin                                  17             17            364
Wellington                               126             90           2939
Bruce                                     32              5           1015
Grey                                      18             28            552
Simcoe                                    62             24           1108
Muskoka                                   14              5            368
Haliburton                                 1              0              3
-----------------------------------------------------------------------------
Totals                                   269            170           6350


                                   Phosphorus     Cyanide        Phenolics
Dufferin                                   1              1              1
Wellington                                14              5              8
Bruce                                      1              1              7
Grey                                       0              1              1
Simcoe                                     3              2              6
Muskoka                                    0              1              2
Haliburton                                 0              0              0
-----------------------------------------------------------------------------
Totals                                    20             10             26


                                   Copper         Lead           Zinc
Dufferin                                   0              0              4
Wellington                                 1              2             42
Bruce                                      0              0             37
Grey                                       0              0              6
Simcoe                                     1              1             34
Muskoka                                    0              0             12
Haliburton                                 0              0              0
-----------------------------------------------------------------------------
Totals                                     3              3            136
```

```
****************************** LINK: Ontario 2.0 ******************************
******************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Base Case
                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Hamilton                                1883           1762         21930
St. Cath-Niag                            394            393          7965
Haldiman-Norfolk                         444            381         11838
Brant                                     92             62          3320
Waterloo                                 191            118          4903
Perth                                     25              9           842
Oxford                                    60             94          1877
Elgin                                     48             29          1544
Kent                                      79            100          2855
Essex                                    228            188          5032
Lambton                                  700            579          7568
Middlesex                                334            235         10558
Huron                                     33             19           362
----------------------------------------------------------------------------
Totals                                  4513           3969         80593

                                   Phosphorus     Cyanide        Phenolics
Hamilton                                  47            136            61
St. Cath-Niag                             27             23            19
Haldiman-Norfolk                          68             28            10
Brant                                     23              2             4
Waterloo                                  14              8            22
Perth                                      3              1             3
Oxford                                     3              4             4
Elgin                                      9              2             3
Kent                                       7              4             7
Essex                                     18             11            15
Lambton                                   96              5             5
Middlesex                                 75             15             7
Huron                                      1              2             1
----------------------------------------------------------------------------
Totals                                   390            240           162

                                   Copper         Lead           Zinc
Hamilton                                   2             13           246
St. Cath-Niag                              1              4            91
Haldiman-Norfolk                           1              2            49
Brant                                      1              1            23
Waterloo                                   1              2           115
Perth                                      0              0            18
Oxford                                     0              0            19
Elgin                                      0              0            14
Kent                                       0              0            37
Essex                                      2              2            75
Lambton                                    6             20            21
Middlesex                                  1              3            42
Huron                                      1              0             6
----------------------------------------------------------------------------
Totals                                    17             49           755
```

****************************** LINK: Ontario 2.0 ******************************
****

Impact in Northeastern Ontario

Year of Expenditure: 1991
Base Case

Contaminants (tonnes)

	Ammonia-N	Oil & Grease	TSS
Nipissing	51	29	1356
Parry Sound	3	1	26
Manitoulin	4	2	12
Sudbury D	66	11	4438
Sudbury RM	372	183	2701
Timiskaming	77	35	258
Cochrane D	175	43	8761
Algoma	670	557	5216
Totals	1418	861	22768

	Phosphorus	Cyanide	Phenolics
Nipissing	11	2	1
Parry Sound	0	0	0
Manitoulin	0	0	0
Sudbury D	36	1	0
Sudbury RM	14	18	3
Timiskaming	0	4	0
Cochrane D	69	5	1
Algoma	9	49	9
Totals	139	79	13

	Copper	Lead	Zinc
Nipissing	1	1	4
Parry Sound	0	0	1
Manitoulin	0	0	0
Sudbury D	1	0	8
Sudbury RM	16	2	24
Timiskaming	4	0	4
Cochrane D	5	0	18
Algoma	10	3	28
Totals	38	7	87

```
******************************* LINK: Ontario 2.0 *******************************
**********************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Base Case

                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Thunder Bay                              282              30           23533
Rainy River D                              2               1               5
Kenora D                                 151              43            8829
------------------------------------------------------------------------------
Totals                                   435              74           32366


                            Contaminants (tonnes)

                                   Phosphorus     Cyanide          Phenolics
Thunder Bay                              189               3               1
Rainy River D                              0               0               0
Kenora D                                  70               4               0
------------------------------------------------------------------------------
Totals                                   259               8               2



                                   Copper         Lead             Zinc
Thunder Bay                                3               0              41
Rainy River D                              0               0               0
Kenora D                                   3               0              15
------------------------------------------------------------------------------
Totals                                     6               1              57
```

```
****************************** LINK: Ontario 2.0 *****************************
******************************************************************************

 Impact in Greater Toronto Area

Year of Expenditure: 1991
Base Case


                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Durham (Oshawa SA)                       106             97           3628
York                                     144            118           3904
Toronto                                 1548            985          58026
Peel                                     355            232          12461
Halton                                   135             89           4924
-----------------------------------------------------------------------------
Totals                                  2288           1522          82943


                                   Phosphorus     Cyanide        Phenolics
Durham (Oshawa SA)                        18              5              5
York                                      16              6             11
Toronto                                  345             40            109
Peel                                      75              9             24
Halton                                    24              5             11
-----------------------------------------------------------------------------
Totals                                   477             65            161


                                   Copper         Lead           Zinc
Durham (Oshawa SA)                         1              1             29
York                                       1              1             55
Toronto                                   10             18            603
Peel                                       3              5            132
Halton                                     2              1             60
-----------------------------------------------------------------------------
Totals                                    16             26            879
```

Scenario 3
Export Lead Growth
Results By Sector

Scenario 3 Date : 09/29/1993
Export Led Growth

Provincial Impact

(Millions)

	Direct	Indirect & Induced	Total
Gross Domestic Product	209803.28	74132.24	283935.52
Gross Sales	172740.71	300079.88	472820.59
Labour Income	43442.30	112121.42	155563.72
Employment (Person Years)	1548786	3172977	4721763

Scenario 3
Export Led Growth

Date : 09/29/1993

Taxes

(Millions)

	Federal	Provincial	Local	Total
Personal Tax	18329.65	8625.72	0.00	26955.36
Indirect Business Tax	0.00	11539.47	0.00	11539.47
Tariffs	4846.51	0.00	0.00	4846.51
Corporate Profit Tax	6563.95	3232.99	0.00	9796.94
Property & Business Tax	0.00	0.00	9989.39	9989.39
Goods & Services Tax	14963.59	0.00	0.00	14963.59
Total Taxes	44703.70	23398.17	9989.39	78091.26

Date : 09/29/1993

Employment by Industry

(Person Years)

Agriculture	204408.67	Forestry	12990.08
Fishing	1995.10	Mining	33544.89
Food	110183.06	Textile	55944.75
Knitting	69402.71	Wood	43314.53
Furniture	36110.57	Paper	65845.17
Print.	85200.53	Prima.	90515.29
Metal	121157.22	Machinery	130693.69
Transportation	239728.29	Electrical P.	119655.48
Non-Metal.	30330.62	Petroleum P.	16877.80
Chemical P.	64115.75	Other	172249.51
Construction	266223.32	Utilities	379390.54
Trade	1184157.58	Services	1187728.11
TOTAL	4721763.24		

Scenario 3
Export Led Growth

Date : 09/29/1993

Industry Output

(Millions)

Agriculture	8016.41	Forestry	1033.18
Fishing	94.17	Mining	2687.70
Food	20290.85	Textile	5585.91
Knitting	2950.08	Wood	2541.18
Furniture	2963.32	Paper	9990.10
Print.	7952.34	Prima.	16272.15
Metal	13866.96	Machinery	17001.54
Transportation	58323.93	Electrical P.	12183.53
Non-Metal.	5104.81	Petroleum P.	13672.78
Chemical P.	15672.99	Other	16390.80
Construction	29701.27	Utilities	40875.76
Trade	75383.90	Travel & Accom.	76019.21
Housing	18245.71	TOTAL	472820.59

Scenario 3
Export Led Growth

Date : 09/29/1993

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Agriculture	0	0	0
Forestry	0	0	0
Fishing	0	0	0
Mining	166017	189178	-23162
Food	268443	240523	27919
Textile	377325	373816	3509
Knitting	0	0	0
Wood	31406	29315	2091
Furniture	0	0	0
Paper	1332621	1250410	82211
Print.	0	0	0
Prima.	1691921	1653618	38303
Metal	68101	65148	2953
Machinery	0	0	0
Transportation	190337	184116	6221
TOTALS	1643064562	1626611897	16452569

Date : 09/29/1993

Scenario 3
Export Led Growth

	Air Emissions (tonnes)		
	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Agriculture	0.02	3.77	0.29
Forestry	0.00	0.00	0.00
Fishing	13.72	7.64	0.11
Mining	1.40	172.50	7.83
Food	1118.53	2017.64	550.29
Textile	1325.70	1738.65	2016.52
Knitting	0.00	0.00	0.00
Wood	0.77	15.49	8.15
Furniture	0.00	0.00	0.00
Paper	4109.08	2862.39	236.32
Print.	32.62	84.28	1.35
Prima.	17933.49	14252.70	3847.34
Metal	1575.54	1122.98	503.87
Machinery	168.88	336.83	1125.27
Transportation	2222.52	1724.98	101.64
TOTALS	564017.67	206315.12	16902.14

Scenario 3
Export Led Growth

Date : 09/29/1993

Energy Used (terajoules)

	Coal	Crude Oil	Natural Gas
Agriculture	10283.54	0.00	13028.91
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	15022.31	0.00	18653.65
Food	9945.47	0.00	45208.08
Textile	2624.06	0.00	11927.90
Knitting	1674.19	0.00	7610.18
Wood	1943.50	0.00	8834.36
Furniture	1295.78	0.00	5890.08
Paper	31509.48	0.00	86709.13
Print.	3068.70	0.00	13949.09
Prima.	282453.82	0.00	98377.33
Metal	6583.02	0.00	29923.76
Machinery	7360.49	0.00	33457.80
Transportation	23364.50	0.00	106205.55
TOTALS	555473.03	1872101.49	928407.34

Scenario 3
Export Led Growth

Date : 09/29/1993

Energy Used (terajoules)

	Electricity	Nuclear Steam	TOTAL
Agriculture	8831.94	3891.93	36036.32
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	8402.03	0.00	42077.99
Food	7262.99	698.47	63115.01
Textile	1916.30	184.29	16652.54
Knitting	1222.63	117.58	10624.57
Wood	1419.30	136.49	12333.65
Furniture	946.28	91.00	8223.14
Paper	22864.83	0.00	141083.44
Print.	2241.02	215.51	19474.32
Prima.	20561.76	0.00	401392.92
Metal	4807.46	462.32	41776.57
Machinery	5375.23	516.93	46710.44
Transportation	17062.66	1640.88	148273.59
TOTALS	225388.46	50220.58	3631590.90

Scenario 3 Date : 09/29/1993
Export Led Growth

Waste Generated (tonnes)

	ONP	Fine Paper	Boxboard
Agriculture	15502.35	32458.05	30035.81
Forestry	985.17	2062.69	1908.76
Fishing	151.31	316.80	293.16
Mining	0.00	0.00	0.00
Food	38678.66	80983.45	74939.91
Textile	2273.59	4760.34	4405.09
Knitting	2820.53	5905.48	5464.77
Wood	3520.61	7371.27	6821.17
Furniture	6759.90	14153.54	13097.30
Paper	8638.89	18087.67	16737.84
Print.	4253.21	8905.16	8240.59
Prima.	15756.90	32991.01	30529.00
Metal	19152.53	40100.62	37108.03
Machinery	7235.20	15148.71	14018.21
Transportation	29074.25	60874.20	56331.35
TOTALS	525868.35	1101036.86	1018869.93

Scenario 3
Export Led Growth

Date : 09/29/1993

Waste Generated (tonnes)

	OCC	Mixed Paper	Magazines
Agriculture	39724.78	7266.73	11626.76
Forestry	2524.49	461.80	738.88
Fishing	387.73	70.93	113.48
Mining	0.00	0.00	0.00
Food	99114.07	18130.62	29009.00
Textile	5826.09	1065.75	1705.20
Knitting	7227.60	1322.12	2115.39
Wood	9021.55	1650.28	2640.45
Furniture	17322.24	3168.70	5069.92
Paper	22137.15	4049.48	6479.16
Print.	10898.85	1993.69	3189.91
Prima.	40377.06	7386.05	11817.68
Metal	49078.37	8977.75	14364.40
Machinery	18540.21	3391.50	5426.40
Transportation	74502.76	13628.55	21805.68
TOTALS	1347537.65	246500.79	394401.26

Scenario 3
Export Led Growth

Date : 09/29/1993

Waste Generated (tonnes)

	Tel. Books	Glass Cont.	Plastic
Agriculture	484.45	5328.93	9204.52
Forestry	30.79	338.65	584.94
Fishing	4.73	52.01	89.84
Mining	0.00	0.00	0.00
Food	1208.71	13295.79	22965.46
Textile	71.05	781.55	1349.95
Knitting	88.14	969.56	1674.69
Wood	110.02	1210.21	2090.36
Furniture	211.25	2323.72	4013.69
Paper	269.97	2969.62	5129.34
Print.	132.91	1462.04	2525.34
Prima.	492.40	5416.44	9355.66
Metal	598.52	6583.68	11371.82
Machinery	226.10	2487.10	4295.90
Transportation	908.57	9994.27	17262.83
TOTALS	16433.39	180767.25	312234.33

Scenario 3
Export Led Growth

Date : 09/29/1993

	Waste Generated (tonnes)		
	Alumin. Cans	Tinplate	Used Tires
Agriculture	1453.35	2422.24	7751.18
Forestry	92.36	153.93	492.58
Fishing	14.19	23.64	75.65
Mining	0.00	0.00	0.00
Food	3626.12	6043.54	19339.33
Textile	213.15	355.25	1136.80
Knitting	264.42	440.71	1410.26
Wood	330.06	550.09	1760.30
Furniture	633.74	1056.23	3379.95
Paper	809.90	1349.83	4319.44
Print.	398.74	664.56	2126.61
Prima.	1477.21	2462.02	7878.45
Metal	1795.55	2992.58	9576.27
Machinery	678.30	1130.50	3617.60
Transportation	2725.71	4542.85	14537.12
TOTALS	49300.16	82166.93	262934.18

Scenario 3
Export Led Growth

Date : 09/29/1993

Waste Generated (tonnes)

	Yard Waste	Food Waste	Wood Waste
Agriculture	10173.42	44084.82	130316.66
Forestry	646.52	2801.57	8281.57
Fishing	99.30	430.28	1271.94
Mining	0.00	0.00	0.00
Food	25382.87	109992.45	325142.51
Textile	1492.05	6465.53	19112.40
Knitting	1850.97	8020.87	23710.05
Wood	2310.40	10011.72	29595.09
Furniture	4436.18	19223.46	56825.40
Paper	5669.27	24566.83	72620.63
Print.	2791.17	12095.07	35753.55
Prima.	10340.47	44808.69	132456.46
Metal	12568.85	54465.02	161000.99
Machinery	4748.10	20575.11	60820.92
Transportation	19079.97	82679.89	244405.39
TOTALS	345101.10	1495438.12	4420580.82

Scenario 3
Export Led Growth

Date : 09/29/1993

Waste Generated (tonnes)

	Demol. Waste	Diapers	Foundry Sand
Agriculture	11626.76	484.45	31973.60
Forestry	738.88	30.79	2031.91
Fishing	113.48	4.73	312.07
Mining	0.00	0.00	0.00
Food	29009.00	1208.71	79774.74
Textile	1705.20	71.05	4689.29
Knitting	2115.39	88.14	5817.33
Wood	2640.45	110.02	7261.25
Furniture	5069.92	211.25	13942.29
Paper	6479.16	269.97	17817.70
Print.	3189.91	132.91	8772.25
Prima.	11817.68	492.40	32498.61
Metal	14364.40	598.52	39502.10
Machinery	5426.40	226.10	14922.61
Transportation	21805.68	908.57	59965.63
TOTALS	394401.26	16433.39	1084603.47

Scenario 3
Export Led Growth

Date : 09/29/1993

	Waste Generated (tonnes)		
	Foundry Sand	Other	TOTAL
Agriculture	31973.60	91560.77	483479.64
Forestry	2031.91	5818.65	30724.92
Fishing	312.07	893.67	4718.93
Mining	0.00	0.00	0.00
Food	79774.74	228445.85	1206290.80
Textile	4689.29	13428.42	70907.73
Knitting	5817.33	16658.73	87965.16
Wood	7261.25	20793.57	109798.87
Furniture	13942.29	39925.66	210824.36
Paper	17817.70	51023.42	269425.25
Print.	8772.25	25120.52	132647.00
Prima.	32498.61	93064.20	491418.38
Metal	39502.10	113119.65	597319.65
Machinery	14922.61	42732.92	225647.88
Transportation	59965.63	171719.77	906753.06
TOTALS	1084603.47	3105909.94	16400519.17

Scenario 3
Export Led Growth

Date : 09/29/1993

DIscharge Contaminants (tonnes)

	Phospurus	Cyanide	Phenolics
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	0.00	64.77	4.37
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	1106.15	0.00	0.00
Print.	0.00	0.00	0.00
Prima.	0.00	338.60	60.73
Metal	4.72	36.27	327.01
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	1455.79	451.28	399.33

Scenario 3
Export Led Growth

Date : 09/29/1993

DIscharge Contaminants (tonnes)

	Amonia-N	Oil & Grease	TSS
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	1262.22	532.62	3420.41
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	1276.35	0.00	135710.90
Print.	0.00	0.00	0.00
Prima.	4090.70	4068.35	28675.87
Metal	1126.72	0.00	44074.84
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	10025.76	7652.11	255866.59

Scenario 3
Export Led Growth

Date : 09/29/1993

DIscharge Contaminants (tonnes)

	Copper	Lead	Zinc
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	68.69	5.69	58.62
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	0.00	0.00	198.45
Print.	0.00	0.00	0.00
Prima.	0.00	22.57	119.14
Metal	1.23	0.00	1694.83
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	88.27	96.85	2098.42

Scenario 3
Export Lead Growth
Results By Region

```
****************************** LINK: Ontario 2.0 ********************************
*********************************************************************************

Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth


                  Demand for Water (thousands of cubic meters)

                                          Intake       Discharge       Net Usage
Stormont, Dundas, Glen                   7518468         7441947           76520
Prescott & Russell                       4187508         4145657           41850
Ottawa-Carleton RM                     149331896       147854075         1477812
Leeds & Grenville                        6227139         6163344           63794
Lanark                                   3635034         3598832           36201
Frontenac                              132742833       131429961         1312864
Lennox & Addington                       2506604         2481501           25104
Hastings (Trenton SA)                    7923098         7843676           79421
Prince Edward (Belleville SA)            1660069         1641521           18549
Northumberland (Cobourg SA)              4918507         4868930           49577
Peterborough                             7650505         7573458           77047
Victoria                                 3804184         3766456           37728
Renfrew                                  6518994         6451796           67198
________________________________________________________________________________
Totals                                 338624839       335261154         3363666



Impact in Central Ontario

Year of Expenditure: 1991
Export Lead Growth


                  Demand for Water (thousands of cubic meters)

                                          Intake       Discharge       Net Usage
Dufferin                                 2362205         2338601           23604
Wellington                              10163282        10059895          103386
Bruce                                    4287392         4244776           42616
Grey                                     5432130         5378102           54027
Simcoe                                  17294858        17122561          172296
Muskoka                                  2897319         2868498           28820
Haliburton                                843986          835647            8339
________________________________________________________________________________
Totals                                  43281172        42848081          433088
```

```
****************************** LINK: Ontario 2.0 *******************************
*********************************************************************************

Impact in Southwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                  Demand for Water (thousands of cubic meters)

                                       Intake      Discharge      Net Usage
Hamilton                             63625712       62979913         645795
St. Cath-Niag                        12878058       12743502         134555
Haldiman-Norfolk                      6760044        6686372          73671
Brant                                 7769763        7689852          79911
Waterloo                             62474345       61851939         622403
Perth                                 4844689        4795865          48824
Oxford                                6193293        6130868          62424
Elgin                                 5100996        5049454          51541
Kent                                  7758191        7679929          78262
Essex                                51261495       50750905         510587
Lambton                               6965482        6853392         112090
Middlesex                            53053811       52521682         532126
Huron                                 4051874        4011735          40139
_____________________________________________________________________________
Totals                              292737753      289745408        2992328


Impact in Northeastern Ontario

Year of Expenditure: 1991
Export Lead Growth


                  Demand for Water (thousands of cubic meters)

                                       Intake      Discharge      Net Usage
Nipissing                             5766443        5708841          57601
Parry Sound                           2471690        2447239          24451
Manitoulin                             723662         716597           7065
Sudbury D                             3312277        3277649          34628
Sudbury RM                           16545030       16386148         158882
Timiskaming                           2906987        2879466          27521
Cochrane D                            6853402        6782852          70549
Algoma                                3919356        3880871          38485
_____________________________________________________________________________
Totals                               42498847       42079661         419183
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                  Demand for Water (thousands of cubic meters)

                                       Intake     Discharge      Net Usage
Thunder Bay                          40743429      40329303         414123
Rainy River D                         1530537       1515442          15094
Kenora D                              3998205       3954938          43266
-----------------------------------------------------------------------------
Totals                               46272171      45799684         472484



 Impact in Greater Toronto Area

Year of Expenditure: 1991
Export Lead Growth


                  Demand for Water (thousands of cubic meters)

                                       Intake     Discharge      Net Usage
Durham (Oshawa SA)                   23680919      23443546         237371
York                                 78010723      77236898         773820
Toronto                             532980206     527653737        5326438
Peel                                184853447     183016871        1836566
Halton                               60125357      59527719         597634
-----------------------------------------------------------------------------
Totals                              879650651     870878770        8771830
```

```
******************************* LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide    Volatile Org C
Stormont, Dundas, Glen                  2593           1429             256
Prescott & Russell                      1715            796              92
Ottawa-Carleton RM                     39843          11802             182
Leeds & Grenville                       2475           1614             249
Lanark                                  1070            435              40
Frontenac                              35236          10135             331
Lennox & Addington                       898            420             163
Hastings (Trenton SA)                   2242            765              53
Prince Edward (Belleville SA)           3834           2470             106
Northumberland (Cobourg SA)             1698            743              85
Peterborough                            2585           1147             126
Victoria                                1181            418              19
Renfrew                                 2070            804              54
-----------------------------------------------------------------------------

Totals                                 97441          32977            1756

 Impact in Central Ontario

Year of Expenditure: 1991
Export Lead Growth


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide    Volatile Org C
Dufferin                                 791            343              26
Wellington                              3714           1793             232
Bruce                                   1198            412              31
Grey                                    1788            664              38
Simcoe                                  4828           1754             203
Muskoka                                  818            269              18
Haliburton                               222             62               1
-----------------------------------------------------------------------------

Totals                                 13358           5298             547
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Southwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Hamilton                               29100          14143           2106
St. Cath-Niag                           9395           4797            621
Haldiman-Norfolk                        4292           2546            408
Brant                                   3871           1767            281
Waterloo                               17918           6210            548
Perth                                   1417            544            105
Oxford                                  2808           1356            168
Elgin                                   1660            672             73
Kent                                    3308           1511             87
Essex                                  15445           5618            320
Lambton                                52618          22249           3796
Middlesex                              15711           5907            386
Huron                                   1158            411             27
____________________________________________________________________________
Totals                                158702          67731           8927


Impact in Northeastern Ontario

Year of Expenditure: 1991
Export Lead Growth


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Nipissing                               1715            704             66
Parry Sound                              654            188              6
Manitoulin                               190             54              1
Sudbury D                                998            346             19
Sudbury RM                              4766           1806             86
Timiskaming                              795            257             12
Cochrane D                              2094            753             24
Algoma                                  3313           2144            479
____________________________________________________________________________
Totals                                 14527           6251            693
```

```
****************************** LINK: Ontario 2.0 *******************************
********************************************************************************

Impact in Northwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Thunder Bay                            11442           3563             75
Rainy River D                            402            113              1
Kenora D                                1410            576             44
----------------------------------------------------------------------------
Totals                                 13255           4251            120




Impact in Greater Toronto Area

Year of Expenditure: 1991
Export Lead Growth


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Durham (Oshawa SA)                      7938           3108            156
York                                   21730           6924            260
Toronto                               167832          57239           3589
Peel                                   51860          16875            634
Halton                                 17376           5661            222
----------------------------------------------------------------------------
Totals                                266735          89806           4860
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth

                            Energy Used (terajoules)

                                           Coal      Crude Oil    Natural Gas
Stormont, Dundas, Glen                   5160              0          12777
Prescott & Russell                       3896              0           6396
Ottawa-Carleton RM                      45092            103         127784
Leeds & Grenville                        8305            466          15112
Lanark                                   2201              0           5309
Frontenac                                7667              0          16240
Lennox & Addington                       1297              0           3981
Hastings (Trenton SA)                    4405              0          11075
Prince Edward (Belleville SA)            4342              0           4491
Northumberland (Cobourg SA)              4719           1275           6913
Peterborough                             5805              0           9276
Victoria                                 1815              0           2793
Renfrew                                  6552              0          13548
-----------------------------------------------------------------------------
Totals                                 101255           1844         235694


                                    Electricity  Nuclear Steam          TOTAL
Stormont, Dundas, Glen                   2863            938          21738
Prescott & Russell                       1782            229          12303
Ottawa-Carleton RM                      37265           3095         213339
Leeds & Grenville                        3208           1259          28350
Lanark                                   1371            253           9134
Frontenac                                4618            297          28821
Lennox & Addington                        996             84           6357
Hastings (Trenton SA)                    3038            277          18794
Prince Edward (Belleville SA)            1033             74           9940
Northumberland (Cobourg SA)              1691            304          14901
Peterborough                             2221            435          17737
Victoria                                  825             96           5529
Renfrew                                  3687            310          24097
-----------------------------------------------------------------------------
Totals                                  64598           7648         411040
```

```
****************************** LINK: Ontario 2.0 ****************************
*****************************************************************************


 Impact in Central Ontario

Year of Expenditure: 1991
Export Lead Growth

                               Energy Used (terajoules)

                                             Coal     Crude Oil    Natural Gas
Dufferin                                    1129             0           2352
Wellington                                  7722          6575          17094
Bruce                                       1519             0           4282
Grey                                        2370            64           4992
Simcoe                                      6793             0          21538
Muskoka                                     1059             0           2976
Haliburton                                   213             0            606
-----------------------------------------------------------------------------
Totals                                     20805          6638          53840


                                      Electricity  Nuclear Steam         TOTAL
Dufferin                                     623           163           4267
Wellington                                  3905          1074          36371
Bruce                                       1239           290           7330
Grey                                        1410           183           9019
Simcoe                                      5544           843          34719
Muskoka                                      743            66           4844
Haliburton                                   177            11           1006
-----------------------------------------------------------------------------
Totals                                     13642          2631          97556
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Southwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                             Energy Used (terajoules)

                                      Coal      Crude Oil    Natural Gas
Hamilton                            127182          73143          84572
St. Cath-Niag                        29127          68759          41807
Haldiman-Norfolk                     28195              0          20902
Brant                                 4652          30088          12377
Waterloo                             14670           4457          36598
Perth                                 2407              0           6759
Oxford                                5607            451           8307
Elgin                                 4879              0          11883
Kent                                  6614              0          11776
Essex                                19407           1114          44409
Lambton                              14565        1221184          54571
Middlesex                            23691              0          41405
Huron                                 2488              0           4700
--------------------------------------------------------------------------
Totals                              283483        1399196         380064


                               Electricity  Nuclear Steam          TOTAL
Hamilton                             19412           3046         307355
St. Cath-Niag                        10395           1854         151941
Haldiman-Norfolk                      5131            545          54772
Brant                                 2786            872          50776
Waterloo                              8684           1464          65873
Perth                                 1779            368          11313
Oxford                                2218            380          16963
Elgin                                 2543            372          19677
Kent                                  2872            375          21636
Essex                                 9760           1521          76210
Lambton                              11282          11307        1312908
Middlesex                            10545           2019          77660
Huron                                 1570            373           9130
--------------------------------------------------------------------------
Totals                               88977          24493        2176215
```

```
******************************* LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Export Lead Growth


                              Energy Used (terajoules)

                                           Coal      Crude Oil    Natural Gas
Nipissing                                3434              0           8585
Parry Sound                               710              0           1943
Manitoulin                                248              0            591
Sudbury D                                1939              0           4982
Sudbury RM                              10924              0          20007
Timiskaming                              1933              0           3320
Cochrane D                               4790              0          11894
Algoma                                  39048            140          21799
------------------------------------------------------------------------------
Totals                                  63026            140          73121


                                   Electricity  Nuclear Steam           TOTAL
Nipissing                                2284            384          14688
Parry Sound                               564             38           3254
Manitoulin                                196             16           1051
Sudbury D                                1422             34           8378
Sudbury RM                               6340            733          38003
Timiskaming                              1093             55           6401
Cochrane D                               3454            135          20274
Algoma                                   5841            124          66952
------------------------------------------------------------------------------
Totals                                  21195           1519         159001
```

```
***************************** LINK: Ontario 2.0 ******************************
*****************************************************************************

Impact in Northwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                             Energy Used (terajoules)

                                         Coal      Crude Oil    Natural Gas
Thunder Bay                             10300              0          27723
Rainy River D                             503              0           1371
Kenora D                                 5708              0          11437
---------------------------------------------------------------------------
Totals                                  16511              0          40531

                                  Electricity  Nuclear Steam          TOTAL
Thunder Bay                              7776            247          46046
Rainy River D                             426             31           2332
Kenora D                                 3195             82          20421
---------------------------------------------------------------------------
Totals                                  11396            361          68800


Impact in Greater Toronto Area

Year of Expenditure: 1991
Export Lead Growth


                             Energy Used (terajoules)

                                         Coal      Crude Oil    Natural Gas
Durham (Oshawa SA)                      16415           3134          49891
York                                    16357            783          37843
Toronto                                116835         433549         308466
Peel                                    27233          18290          73695
Halton                                  14321           8524          39683
---------------------------------------------------------------------------
Totals                                 191160         464280         509579
```

```
                                         Coal      Crude Oil    Natural Gas
Durham (Oshawa SA)                      16415           3134          49891
York                                    16357            783          37843
Toronto                                116835         433549         308466
Peel                                    27233          18290          73695
Halton                                  14321           8524          39683
---------------------------------------------------------------------------
Totals                                 191160         464280         509579
```

```
****************************** LINK: Ontario 2.0 *****************************
*****************************************************************************

Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth
                              Waste Generated (tonnes)

                                         ONP      Fine Paper          Boxboard
Stormont, Dundas, Glen                  5565           11652             10783
Prescott & Russell                      2316            4849              4487
Ottawa-Carleton RM                     29980           62771             58087
Leeds & Grenville                       4455            9327              8631
Lanark                                  1767            3701              3424
Frontenac                               7488           15678             14508
Lennox & Addington                      1369            2867              2653
Hastings (Trenton SA)                   3386            7089              6560
Prince Edward (Belleville SA)           2329            4877              4513
Northumberland (Cobourg SA)             2943            6162              5702
Peterborough                            3924            8215              7602
Victoria                                1670            3497              3236
Renfrew                                 2814            5891              5451
______________________________________________________________________________
Totals                                 70006          146576            135637

                                         OCC     Mixed Paper         Magazines
Stormont, Dundas, Glen                 14261            2609              4174
Prescott & Russell                      5935            1086              1737
Ottawa-Carleton RM                     76824           14053             22485
Leeds & Grenville                      11415            2088              3341
Lanark                                  4529             828              1326
Frontenac                              19188            3510              5616
Lennox & Addington                      3509             642              1027
Hastings (Trenton SA)                   8677            1587              2539
Prince Edward (Belleville SA)           5969            1092              1747
Northumberland (Cobourg SA)             7542            1380              2207
Peterborough                           10054            1839              2943
Victoria                                4279             783              1253
Renfrew                                 7210            1319              2110
______________________________________________________________________________
Totals                                179391           32815             52505

                                  Tel. Books     Glass Cont.           Plastic
Stormont, Dundas, Glen                   174            1913              3304
Prescott & Russell                        72             796              1375
Ottawa-Carleton RM                       937           10306             17801
Leeds & Grenville                        139            1531              2645
Lanark                                    55             608              1049
Frontenac                                234            2574              4446
Lennox & Addington                        43             471               813
Hastings (Trenton SA)                    106            1164              2010
Prince Edward (Belleville SA)             73             801              1383
Northumberland (Cobourg SA)               92            1012              1748
Peterborough                             123            1349              2330
Victoria                                  52             574               992
Renfrew                                   88             967              1671
______________________________________________________________________________
Totals                                  2188           24065             41566
```

```
******************************* LINK: Ontario 2.0 *******************************
*********************************************************************************

Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth
                             Waste Generated (tonnes)

                              Alumin. Cans          Tinplate         Used Tires
Stormont, Dundas, Glen                 522               870               2783
Prescott & Russell                     217               362               1158
Ottawa-Carleton RM                    2811              4684              14990
Leeds & Grenville                      418               696               2227
Lanark                                 166               276                884
Frontenac                              702              1170               3744
Lennox & Addington                     128               214                685
Hastings (Trenton SA)                  317               529               1693
Prince Edward (Belleville SA)          218               364               1165
Northumberland (Cobourg SA)            276               460               1472
Peterborough                           368               613               1962
Victoria                               157               261                835
Renfrew                                264               440               1407
_______________________________________________________________________________

Totals                                6563             10938              35003

                                Yard Waste        Food Waste         Wood Waste
Stormont, Dundas, Glen                3652             15826              46782
Prescott & Russell                    1520              6586              19469
Ottawa-Carleton RM                   19675             85256             252021
Leeds & Grenville                     2923             12668              37446
Lanark                                1160              5026              14858
Frontenac                             4914             21294              62945
Lennox & Addington                     899              3894              11510
Hastings (Trenton SA)                 2222              9629              28463
Prince Edward (Belleville SA)         1529              6624              19582
Northumberland (Cobourg SA)           1931              8370              24741
Peterborough                          2575             11158              32983
Victoria                              1096              4749              14039
Renfrew                               1846              8001              23652
_______________________________________________________________________________

Totals                               45942            199081             588491

                              Demol. Waste           Diapers       Foundry Sand
Stormont, Dundas, Glen                4174               174              11478
Prescott & Russell                    1737                72               4777
Ottawa-Carleton RM                   22485               937              61834
Leeds & Grenville                     3341               139               9187
Lanark                                1326                55               3645
Frontenac                             5616               234              15444
Lennox & Addington                    1027                43               2824
Hastings (Trenton SA)                 2539               106               6984
Prince Edward (Belleville SA)         1747                73               4805
Northumberland (Cobourg SA)           2207                92               6070
Peterborough                          2943               123               8092
Victoria                              1253                52               3444
Renfrew                               2110                88               5803
_______________________________________________________________________________

Totals                               52505              2188             144388
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth


                            Waste Generated (tonnes)

                                      Other           TOTAL
Stormont, Dundas, Glen                   32869        173564
Prescott & Russell                       13679         72232
Ottawa-Carleton RM                      177071        935009
Leeds & Grenville                        26309        138925
Lanark                                   10439         55123
Frontenac                                44225        233528
Lennox & Addington                        8087         42702
Hastings (Trenton SA)                    19998        105600
Prince Edward (Belleville SA)            13758         72650
Northumberland (Cobourg SA)              17383         91791
Peterborough                             23174        122366
Victoria                                  9864         52084
Renfrew                                  16618         87750
______________________________________________________________________________
Totals                                  413475       2183324
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

Impact in Central Ontario

Year of Expenditure: 1991
Export Lead Growth

                             Waste Generated (tonnes)

                                       ONP       Fine Paper          Boxboard
Dufferin                              1299             2719              2517
Wellington                            7585            15882             14696
Bruce                                 2801             5865              5427
Grey                                  3002             6285              5816
Simcoe                                9524            19940             18452
Muskoka                               1688             3534              3270
Haliburton                             368              770               712
------------------------------------------------------------------------------
Totals                               26266            54995             50891


                                       OCC      Mixed Paper         Magazines
Dufferin                              3328              609               974
Wellington                           19437             3556              5689
Bruce                                 7178             1313              2101
Grey                                  7692             1407              2251
Simcoe                               24404             4464              7143
Muskoka                               4325              791              1266
Haliburton                             942              172               276
------------------------------------------------------------------------------
Totals                               67307            12312             19700


                                Tel. Books      Glass Cont.           Plastic
Dufferin                                41              446               771
Wellington                             237             2607              4504
Bruce                                   88              963              1663
Grey                                    94             1032              1782
Simcoe                                 298             3274              5655
Muskoka                                 53              580              1002
Haliburton                              11              126               218
------------------------------------------------------------------------------
Totals                                 821             9029             15596


                              Alumin. Cans         Tinplate        Used Tires
Dufferin                               122              203               649
Wellington                             711             1185              3793
Bruce                                  263              438              1401
Grey                                   281              469              1501
Simcoe                                 893             1488              4762
Muskoka                                158              264               844
Haliburton                              34               57               184
------------------------------------------------------------------------------
Totals                                2462             4104             13133
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Central Ontario

Year of Expenditure: 1991
Export Lead Growth

                            Waste Generated (tonnes)

                                 Yard Waste       Food Waste       Wood Waste
Dufferin                                  852           3694          10919
Wellington                               4978          21571          63764
Bruce                                    1838           7965          23546
Grey                                     1970           8536          25234
Simcoe                                   6250          27083          80058
Muskoka                                  1108           4800          14189
Haliburton                                241           1045           3090
-----------------------------------------------------------------------------
Totals                                  17237          74694         220800


                               Demol. Waste          Diapers     Foundry Sand
Dufferin                                  974             41           2679
Wellington                               5689            237          15645
Bruce                                    2101             88           5777
Grey                                     2251             94           6191
Simcoe                                   7143            298          19643
Muskoka                                  1266             53           3481
Haliburton                                276             11            758
-----------------------------------------------------------------------------
Totals                                  19700            821          54174


                                      Other            TOTAL
Dufferin                                 7671          40508
Wellington                              44801         236566
Bruce                                   16543          87356
Grey                                    17730          93620
Simcoe                                  56249         297018
Muskoka                                  9969          52641
Haliburton                               2171          11465
-----------------------------------------------------------------------------
Totals                                 155134         819176
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Southwestern Ontario
Year of Expenditure: 1991
Export Lead Growth
                             Waste Generated (tonnes)

                                       ONP      Fine Paper          Boxboard
Hamilton                             30059           62936             58239
St. Cath-Niag                        18325           38368             35505
Haldiman-Norfolk                      6193           12966             11999
Brant                                 4380            9170              8486
Waterloo                             21625           45276             41898
Perth                                 4097            8578              7938
Oxford                                4273            8947              8279
Elgin                                 4492            9406              8704
Kent                                  5185           10856             10046
Essex                                18266           38244             35390
Lambton                               8610           18027             16681
Middlesex                            18294           38303             35445
Huron                                 2863            5995              5547
-----------------------------------------------------------------------------
Totals                              146661          307072            284156

                                       OCC     Mixed Paper         Magazines
Hamilton                             77026           14090             22544
St. Cath-Niag                        46958            8590             13744
Haldiman-Norfolk                     15869            2903              4645
Brant                                11223            2053              3285
Waterloo                             55413           10137             16218
Perth                                10498            1920              3073
Oxford                               10950            2003              3205
Elgin                                11512            2106              3369
Kent                                 13286            2430              3889
Essex                                46807            8562             13699
Lambton                              22062            4036              6457
Middlesex                            46879            8575             13721
Huron                                 7337            1342              2147
-----------------------------------------------------------------------------
Totals                              375819           68747            109996

                                Tel. Books     Glass Cont.           Plastic
Hamilton                               939           10333             17848
St. Cath-Niag                          573            6299             10880
Haldiman-Norfolk                       194            2129              3677
Brant                                  137            1505              2600
Waterloo                               676            7433             12840
Perth                                  128            1408              2433
Oxford                                 134            1469              2537
Elgin                                  140            1544              2667
Kent                                   162            1782              3078
Essex                                  571            6279             10845
Lambton                                269            2960              5112
Middlesex                              572            6289             10862
Huron                                   89             984              1700
-----------------------------------------------------------------------------
Totals                                4583           50415             87080
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Southwestern Ontario

Year of Expenditure: 1991
Export Lead Growth
                            Waste Generated (tonnes)

                              Alumin. Cans          Tinplate        Used Tires
Hamilton                              2818              4697             15029
St. Cath-Niag                         1718              2863              9162
Haldiman-Norfolk                       581               968              3096
Brant                                  411               684              2190
Waterloo                              2027              3379             10812
Perth                                  384               640              2048
Oxford                                 401               668              2137
Elgin                                  421               702              2246
Kent                                   486               810              2592
Essex                                 1712              2854              9133
Lambton                                807              1345              4305
Middlesex                             1715              2858              9147
Huron                                  268               447              1432
______________________________________________________________________________

Totals                               13749             22916             73331

                                Yard Waste        Food Waste        Wood Waste
Hamilton                             19726             85480            252683
St. Cath-Niag                        12026             52112            154044
Haldiman-Norfolk                      4064             17611             52058
Brant                                 2874             12455             36816
Waterloo                             14191             61495            181781
Perth                                 2689             11651             34439
Oxford                                2804             12152             35921
Elgin                                 2948             12775             37764
Kent                                  3403             14744             43585
Essex                                11987             51944            153549
Lambton                               5650             24484             72375
Middlesex                            12006             52024            153786
Huron                                 1879              8142             24068
______________________________________________________________________________

Totals                               96246            417068           1232871

                              Demol. Waste           Diapers      Foundry Sand
Hamilton                             22544               939             61997
St. Cath-Niag                        13744               573             37795
Haldiman-Norfolk                      4645               194             12773
Brant                                 3285               137              9033
Waterloo                             16218               676             44601
Perth                                 3073               128              8450
Oxford                                3205               134              8813
Elgin                                 3369               140              9266
Kent                                  3889               162             10694
Essex                                13699               571             37674
Lambton                               6457               269             17757
Middlesex                            13721               572             37732
Huron                                 2147                89              5905
______________________________________________________________________________

Totals                              109996              4583            302489
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Southwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                            Waste Generated (tonnes)

                                      Other             TOTAL
Hamilton                             177536            937464
St. Cath-Niag                        108232            571509
Haldiman-Norfolk                      36576            193139
Brant                                 25867            136590
Waterloo                             127720            674416
Perth                                 24197            127772
Oxford                                25238            133270
Elgin                                 26533            140107
Kent                                  30623            161701
Essex                                107884            569671
Lambton                               50851            268515
Middlesex                            108050            570550
Huron                                 16911             89295
-----------------------------------------------------------------------------
Totals                               866218           4573998
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Northeastern Ontario

Year of Expenditure: 1991
Export Lead Growth

                              Waste Generated (tonnes)

                                        ONP      Fine Paper          Boxboard
Nipissing                              2134            4467              4134
Parry Sound                             973            2037              1885
Manitoulin                              218             456               422
Sudbury D                              1193            2497              2311
Sudbury RM                             5832           12211             11299
Timiskaming                            1210            2533              2344
Cochrane D                             2788            5838              5402
Algoma                                 5525           11568             10705
-----------------------------------------------------------------------------
Totals                                19872           41606             38501

                                        OCC     Mixed Paper         Magazines
Nipissing                              5467            1000              1600
Parry Sound                            2493             456               730
Manitoulin                              558             102               163
Sudbury D                              3056             559               895
Sudbury RM                            14944            2734              4374
Timiskaming                            3100             567               907
Cochrane D                             7145            1307              2091
Algoma                                14158            2590              4144
-----------------------------------------------------------------------------
Totals                                50921            9315             14904

                                 Tel. Books     Glass Cont.           Plastic
Nipissing                                67             733              1267
Parry Sound                              30             334               578
Manitoulin                                7              75               129
Sudbury D                                37             410               708
Sudbury RM                              182            2005              3463
Timiskaming                              38             416               718
Cochrane D                               87             958              1655
Algoma                                  173            1899              3281
-----------------------------------------------------------------------------
Totals                                  621            6831             11799

                               Alumin. Cans        Tinplate        Used Tires
Nipissing                               200             333              1067
Parry Sound                              91             152               486
Manitoulin                               20              34               109
Sudbury D                               112             186               596
Sudbury RM                              547             911              2916
Timiskaming                             113             189               605
Cochrane D                              261             436              1394
Algoma                                  518             863              2763
-----------------------------------------------------------------------------
Totals                                 1863            3105              9936
```

```
****************************** LINK: Ontario 2.0 ********************************
*********************************************************************************

Impact in Northeastern Ontario

Year of Expenditure: 1991
Export Lead Growth

                              Waste Generated (tonnes)

                                 Yard Waste        Food Waste        Wood Waste
Nipissing                              1400              6067             17935
Parry Sound                             638              2767              8179
Manitoulin                              143               619              1829
Sudbury D                               783              3392             10026
Sudbury RM                             3827             16585             49025
Timiskaming                             794              3440             10169
Cochrane D                             1830              7929             23438
Algoma                                 3626             15712             46446
_______________________________________________________________________________
Totals                                13041             56510            167047


                               Demol. Waste           Diapers     Foundry Sand
Nipissing                              1600                67             4400
Parry Sound                             730                30             2007
Manitoulin                              163                 7              449
Sudbury D                               895                37             2460
Sudbury RM                             4374               182            12028
Timiskaming                             907                38             2495
Cochrane D                             2091                87             5751
Algoma                                 4144               173            11396
_______________________________________________________________________________
Totals                                14904               621            40985


                                      Other             TOTAL
Nipissing                             12601             66539
Parry Sound                            5746             30343
Manitoulin                             1285              6786
Sudbury D                              7044             37197
Sudbury RM                            34445            181884
Timiskaming                            7145             37727
Cochrane D                            16468             86957
Algoma                                32633            172316
_______________________________________________________________________________
Totals                               117367            619749
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Northwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                            Waste Generated (tonnes)

                                        ONP       Fine Paper         Boxboard
Thunder Bay                          7030          14720          13621
Rainy River D                         484           1013            937
Kenora D                             1932           4045           3743
-----------------------------------------------------------------------------
Totals                               9446          19777          18301

                                        OCC      Mixed Paper        Magazines
Thunder Bay                         18015           3295           5273
Rainy River D                        1239            227            363
Kenora D                             4950            906           1449
-----------------------------------------------------------------------------
Totals                              24205           4428           7084

                                  Tel. Books     Glass Cont.          Plastic
Thunder Bay                           220           2417           4174
Rainy River D                          15            166            287
Kenora D                               60            664           1147
-----------------------------------------------------------------------------
Totals                                295           3247           5608

                                Alumin. Cans        Tinplate       Used Tires
Thunder Bay                           659           1098           3515
Rainy River D                          45             76            242
Kenora D                              181            302            966
-----------------------------------------------------------------------------
Totals                                886           1476           4723

                                  Yard Waste      Food Waste       Wood Waste
Thunder Bay                          4614          19992          59098
Rainy River D                         317           1376           4066
Kenora D                             1268           5493          16239
-----------------------------------------------------------------------------
Totals                               6199          26861          79403

                                Demol. Waste         Diapers     Foundry Sand
Thunder Bay                          5273            220          14500
Rainy River D                         363             15            998
Kenora D                             1449             60           3984
-----------------------------------------------------------------------------
Totals                               7084            295          19482

                                       Other           TOTAL
Thunder Bay                         41523         219257
Rainy River D                        2857          15085
Kenora D                            11409          60247
-----------------------------------------------------------------------------
Totals                              55789         294590
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

Impact in Greater Toronto Area

Year of Expenditure: 1991
Export Lead Growth

                             Waste Generated (tonnes)

                                        ONP      Fine Paper          Boxboard
Durham (Oshawa SA)                    17202           36016             33329
York                                  22576           47268             43740
Toronto                              158629          332130            307344
Peel                                  36872           77201             71440
Halton                                18339           38396             35531
------------------------------------------------------------------------------
Totals                               253617          531012            491384


                                        OCC     Mixed Paper         Magazines
Durham (Oshawa SA)                    44080            8063             12901
York                                  57850           10582             16932
Toronto                              406487           74357            118972
Peel                                  94485           17284             27654
Halton                                46993            8596             13754
------------------------------------------------------------------------------
Totals                               649895          118883            190213


                                 Tel. Books     Glass Cont.           Plastic
Durham (Oshawa SA)                      538            5913             10214
York                                    705            7760             13404
Toronto                                4957           54529             94186
Peel                                   1152           12675             21893
Halton                                  573            6304             10889
------------------------------------------------------------------------------
Totals                                 7926           87181            150585


                               Alumin. Cans        Tinplate        Used Tires
Durham (Oshawa SA)                     1613            2688              8601
York                                   2116            3527             11288
Toronto                               14871           24786             79315
Peel                                   3457            5761             18436
Halton                                 1719            2865              9169
------------------------------------------------------------------------------
Totals                                23777           39628            126809
```

```
****************************** LINK: Ontario 2.0 *****************************
******************************************************************************

Impact in Greater Toronto Area

Year of Expenditure: 1991
Export Lead Growth


                              Waste Generated (tonnes)

                                  Yard Waste      Food Waste      Wood Waste
Durham (Oshawa SA)                     11289           48918          144603
York                                   14815           64200          189777
Toronto                               104100          451102         1333476
Peel                                   24197          104855          309957
Halton                                 12035           52150          154159
____________________________________________________________________________

Totals                                166436          721225         2131972


                                Demol. Waste         Diapers    Foundry Sand
Durham (Oshawa SA)                     12901             538           35479
York                                   16932             705           46562
Toronto                               118972            4957          327173
Peel                                   27654            1152           76049
Halton                                 13754             573           37823
____________________________________________________________________________

Totals                                190213            7926          523086


                                       Other           TOTAL
Durham (Oshawa SA)                    101598          536481
York                                  133338          704080
Toronto                               936903         4947246
Peel                                  217777         1149954
Halton                                108312          571934
____________________________________________________________________________

Totals                               1497928         7909695
```

```
******************************* LINK: Ontario 2.0 *******************************
*********************************************************************************

Impact in Eastern Ontario

Year of Expenditure: 1991
Export Lead Growth
                              Contaminants (tonnes)

                                     Ammonia-N      Oil & Grease   TSS
Stormont, Dundas, Glen                      80               64          1332
Prescott & Russell                          36               56           926
Ottawa-Carleton RM                         100               72          2141
Leeds & Grenville                          154              120          2726
Lanark                                      28               18           427
Frontenac                                   47               42           956
Lennox & Addington                           8                8           675
Hastings (Trenton SA)                       35               19          1401
Prince Edward (Belleville SA)               27              223          3651
Northumberland (Cobourg SA)                 61               55           866
Peterborough                                89               77          2039
Victoria                                    18               21           286
Renfrew                                     91               42          5238
-----------------------------------------------------------------------------
Totals                                     774              818         22665

                                     Phosphorus     Cyanide        Phenolics
Stormont, Dundas, Glen                       9                3             3
Prescott & Russell                           2                2             1
Ottawa-Carleton RM                          15                3             4
Leeds & Grenville                           20                6             4
Lanark                                       2                1             2
Frontenac                                    3                3             2
Lennox & Addington                           4                0             0
Hastings (Trenton SA)                       10                1             1
Prince Edward (Belleville SA)                2                2             1
Northumberland (Cobourg SA)                  3                4             2
Peterborough                                11                5             3
Victoria                                     0                1             0
Renfrew                                     41                3             1
-----------------------------------------------------------------------------
Totals                                     121               35            24

                                     Copper         Lead           Zinc
Stormont, Dundas, Glen                       1                1            15
Prescott & Russell                           0                0             5
Ottawa-Carleton RM                           1                2            19
Leeds & Grenville                            1                2            17
Lanark                                       0                0             9
Frontenac                                    0                0            11
Lennox & Addington                           0                0             3
Hastings (Trenton SA)                        0                0             5
Prince Edward (Belleville SA)                0                0             5
Northumberland (Cobourg SA)                  0                1             9
Peterborough                                 1                1            13
Victoria                                     0                0             2
Renfrew                                      0                0            10
-----------------------------------------------------------------------------
Totals                                       5                9           122
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Export Lead Growth

                             Contaminants (tonnes)

                                    Ammonia-N       Oil & Grease   TSS
Dufferin                                   17                 17          376
Wellington                                130                 94         3041
Bruce                                      33                  5         1047
Grey                                       19                 29          569
Simcoe                                     64                 25         1144
Muskoka                                    14                  5          379
Haliburton                                  1                  0            3
_____________________________________________________________________________

Totals                                    279                176         6559


                                    Phosphorus      Cyanide        Phenolics
Dufferin                                    1                  1            1
Wellington                                 15                  5            9
Bruce                                       1                  1            7
Grey                                        0                  1            1
Simcoe                                      3                  2            7
Muskoka                                     0                  1            2
Haliburton                                  0                  0            0
_____________________________________________________________________________

Totals                                     21                 10           27


                                    Copper          Lead           Zinc
Dufferin                                    0                  0            4
Wellington                                  1                  2           44
Bruce                                       0                  0           38
Grey                                        0                  0            6
Simcoe                                      1                  1           35
Muskoka                                     0                  0           13
Haliburton                                  0                  0            0
_____________________________________________________________________________

Totals                                      3                  3          140
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

Impact in Southwestern Ontario

Year of Expenditure: 1991
Export Lead Growth
                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Hamilton                                1955           1829          22721
St. Cath-Niag                            408            407           8237
Haldiman-Norfolk                         461            395          12286
Brant                                     96             64           3441
Waterloo                                 198            122           5064
Perth                                     26              9            871
Oxford                                    63             97           1936
Elgin                                     50             30           1602
Kent                                      82            103           2948
Essex                                    237            194           5203
Lambton                                  724            599           7822
Middlesex                                347            244          10960
Huron                                     35             20            374
-----------------------------------------------------------------------------
Totals                                  4680           4114          83467

                                   Phosphorus     Cyanide        Phenolics
Hamilton                                  49            141             63
St. Cath-Niag                             28             23             20
Haldiman-Norfolk                          70             29             10
Brant                                     24              2              4
Waterloo                                  14              8             23
Perth                                      3              1              3
Oxford                                     3              4              4
Elgin                                      9              2              3
Kent                                       7              5              7
Essex                                     19             12             15
Lambton                                  100              5              5
Middlesex                                 78             15              8
Huron                                      1              2              1
-----------------------------------------------------------------------------
Totals                                   405            249            167

                                   Copper         Lead           Zinc
Hamilton                                   2             14            254
St. Cath-Niag                              1              4             94
Haldiman-Norfolk                           1              2             50
Brant                                      1              1             24
Waterloo                                   1              2            118
Perth                                      0              0             18
Oxford                                     0              0             19
Elgin                                      0              0             14
Kent                                       0              0             38
Essex                                      2              2             77
Lambton                                    6             21             22
Middlesex                                  1              3             43
Huron                                      1              0              6
-----------------------------------------------------------------------------
Totals                                    18             50            780
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Northeastern Ontario

Year of Expenditure: 1991
Export Lead Growth

                            Contaminants (tonnes)

                                    Ammonia-N      Oil & Grease   TSS
Nipissing                                  53             30           1407
Parry Sound                                 3              2             27
Manitoulin                                  5              2             12
Sudbury D                                  69             11           4612
Sudbury RM                                386            189           2802
Timiskaming                                80             37            268
Cochrane D                                182             45           9103
Algoma                                    696            579           5416
_____________________________________________________________________________

Totals                                   1473            894          23648


                                    Phosphorus     Cyanide        Phenolics
Nipissing                                  11              2              1
Parry Sound                                 0              0              0
Manitoulin                                  0              0              0
Sudbury D                                  37              1              0
Sudbury RM                                 14             19              3
Timiskaming                                 0              4              0
Cochrane D                                 72              5              1
Algoma                                     10             51              9
_____________________________________________________________________________

Totals                                    144             82             14


                                    Copper         Lead           Zinc
Nipissing                                   1              1              4
Parry Sound                                 0              0              1
Manitoulin                                  0              0              0
Sudbury D                                   1              0              8
Sudbury RM                                 17              3             25
Timiskaming                                 4              0              4
Cochrane D                                  5              1             19
Algoma                                     10              4             30
_____________________________________________________________________________

Totals                                     39              8             90
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

Impact in Northwestern Ontario

Year of Expenditure: 1991
Export Lead Growth


                             Contaminants (tonnes)

                                    Ammonia-N      Oil & Grease   TSS
Thunder Bay                               293                31        24452
Rainy River D                               2                 1            5
Kenora D                                  157                45         9174
-----------------------------------------------------------------------------
Totals                                    452                77        33631



                                    Phosphorus     Cyanide             Phenolics
Thunder Bay                               197                 3             1
Rainy River D                               0                 0             0
Kenora D                                   72                 4             1
-----------------------------------------------------------------------------
Totals                                    269                 8             2



                                    Copper         Lead                Zinc
Thunder Bay                                 3                 0            43
Rainy River D                               0                 0             0
Kenora D                                    3                 0            16
-----------------------------------------------------------------------------
Totals                                      6                 1            59
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

Impact in Greater Toronto Area

Year of Expenditure: 1991
Export Lead Growth

                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Durham (Oshawa SA)                       110            101           3757
York                                     149            122           4037
Toronto                                 1602           1019          60102
Peel                                     367            240          12905
Halton                                   140             92           5097
-----------------------------------------------------------------------------
Totals                                  2369           1574          85898


                                   Phosphorus     Cyanide        Phenolics
Durham (Oshawa SA)                        19              5              6
York                                      16              7             11
Toronto                                  358             42            113
Peel                                      78              9             25
Halton                                    25              5             11
-----------------------------------------------------------------------------
Totals                                   495             67            166


                                   Copper         Lead           Zinc
Durham (Oshawa SA)                         1              1             30
York                                       1              1             57
Toronto                                   10             19            622
Peel                                       3              5            137
Halton                                     2              1             62
-----------------------------------------------------------------------------
Totals                                    17             27            907
```

Scenario 4

Substitution Of $1 Billion In Sales Of Plastic For $1 Billion In Sales Of Steel

Results By Sector

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Provincial Impact

(Millions)

	Direct	Indirect & Induced	Total
Gross Domestic Product	204087.03	73296.05	277383.08
Gross Sales	167030.00	291981.47	459011.47
Labour Income	42002.69	109973.63	151976.33
Employment (Person Years)	1503738	3089246	4592984

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Taxes

(Millions)

	Federal	Provincial	Local	Total
Personal Tax	17906.95	8426.80	0.00	26333.76
Indirect Business Tax	0.00	11293.08	0.00	11293.08
Tariffs	4727.51	0.00	0.00	4727.51
Corporate Profit Tax	6372.85	3138.87	0.00	9511.72
Property & Business Tax	0.00	0.00	9776.10	9776.10
Goods & Services Tax	14616.89	0.00	0.00	14616.89
Total Taxes	43624.21	22858.75	9776.10	76259.06

Date : 09/29/1993

Employment by Industry

(Person Years)

Agriculture	198086.19	Forestry	12568.81
Fishing	1923.06	Mining	31513.83
Food	106698.43	Textile	54138.74
Knitting	67326.51	Wood	42002.40
Furniture	35166.02	Paper	63584.29
Print.	82641.30	Prima.	81255.08
Metal	117525.15	Machinery	127395.06
Transportation	230291.70	Electrical P.	116323.32
Non-Metal.	29441.47	Petroleum P.	16395.97
Chemical P.	62454.79	Other	175549.67
Construction	264601.96	Utilities	367868.47
Trade	1153541.20	Services	1154690.48
TOTAL	4592983.91		

```
Scenario 4                                                    Date : 09/29/1993
 Substitution of $1B Plastic for Steel
                                  Industry Output
                                  ---------------
                                  (Millions)

 Agriculture               7768.46    Forestry                   999.68
 Fishing                     90.77    Mining                    2524.96
 Food                     19649.14    Textile                   5405.59
 Knitting                  2861.83    Wood                      2464.20
 Furniture                 2885.81    Paper                     9647.08
 Print.                    7713.47    Prima.                   14607.42
 Metal                    13451.26    Machinery                16572.43
 Transportation           56028.08    Electrical P.            11844.25
 Non-Metal.                4955.17    Petroleum P.             13282.45
 Chemical P.              15266.97    Other                    16704.84
 Construction             29520.39    Utilities                39634.36
 Trade                    73434.85    Travel & Accom.          73843.44
 Housing                  17854.59    TOTAL                   459011.47
```

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Agriculture	0	0	0
Forestry	0	0	0
Fishing	0	0	0
Mining	155965	177724	-21759
Food	259953	232917	27036
Textile	365144	361748	3396
Knitting	0	0	0
Wood	30455	28427	2028
Furniture	0	0	0
Paper	1286864	1207475	79388
Print.	0	0	0
Prima.	1518828	1484443	34385
Metal	66059	63195	2864
Machinery	0	0	0
Transportation	182845	176869	5976
TOTALS	1593050197	1577098345	15951759

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

		Air Emissions (tonnes)	
	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Agriculture	0.02	3.66	0.28
Forestry	0.00	0.00	0.00
Fishing	13.22	7.37	0.11
Mining	1.32	162.05	7.35
Food	1083.16	1953.83	532.88
Textile	1282.90	1682.52	1951.42
Knitting	0.00	0.00	0.00
Wood	0.74	15.02	7.90
Furniture	0.00	0.00	0.00
Paper	3967.99	2764.11	228.21
Print.	31.64	81.75	1.30
Prima.	16098.80	12794.57	3453.74
Metal	1528.31	1089.31	488.76
Machinery	164.62	328.33	1096.87
Transportation	2135.03	1657.08	97.64
TOTALS	545796.42	199212.71	16174.44

Scenario 4 Date : 09/29/1993
Substitution of $1B Plastic for Steel

	Energy Used (terajoules)		
	Coal	Crude Oil	Natural Gas
Agriculture	9965.47	0.00	12625.92
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	14112.75	0.00	17524.22
Food	9630.94	0.00	43778.34
Textile	2539.35	0.00	11542.84
Knitting	1624.10	0.00	7382.52
Wood	1884.62	0.00	8566.74
Furniture	1261.88	0.00	5736.01
Paper	30427.56	0.00	83731.86
Print.	2976.53	0.00	13530.09
Prima.	253557.26	0.00	88312.80
Metal	6385.68	0.00	29026.70
Machinery	7174.71	0.00	32613.35
Transportation	22444.79	0.00	102024.91
TOTALS	518374.87	1818656.42	894621.03

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

	Energy Used (terajoules)		
	Electricity	Nuclear Steam	TOTAL
Agriculture	8558.76	3771.55	34921.70
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	7893.31	0.00	39530.28
Food	7033.29	676.38	61118.95
Textile	1854.44	178.34	16114.97
Knitting	1186.05	114.06	10306.73
Wood	1376.31	132.36	11960.02
Furniture	921.53	88.62	8008.04
Paper	22079.74	0.00	136239.16
Print.	2173.70	209.04	18889.36
Prima.	18458.18	0.00	360328.24
Metal	4663.34	448.46	40524.18
Machinery	5239.56	503.88	45531.50
Transportation	16391.01	1576.29	142437.00
TOTALS	217240.76	48886.65	3497779.73

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Waste Generated (tonnes)

	ONP	Fine Paper	Boxboard
Agriculture	15022.86	31454.11	29106.78
Forestry	953.22	1995.80	1846.86
Fishing	145.84	305.36	282.57
Mining	0.00	0.00	0.00
Food	37455.42	78422.28	72569.87
Textile	2200.20	4606.67	4262.88
Knitting	2736.15	5728.81	5301.29
Wood	3413.96	7147.97	6614.54
Furniture	6583.08	13783.32	12754.72
Paper	8342.26	17466.60	16163.13
Print.	4125.45	8637.67	7993.07
Prima.	14144.89	29615.85	27405.71
Metal	18578.38	38898.47	35995.60
Machinery	7052.59	14766.36	13664.39
Transportation	27929.78	58477.97	54113.94
TOTALS	512682.49	1073428.96	993322.32

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Waste Generated (tonnes)

	OCC	Mixed Paper	Magazines
Agriculture	38496.07	7041.96	11267.14
Forestry	2442.62	446.82	714.91
Fishing	373.73	68.36	109.38
Mining	0.00	0.00	0.00
Food	95979.51	17557.23	28091.56
Textile	5638.01	1031.34	1650.15
Knitting	7011.38	1282.57	2052.11
Wood	8748.26	1600.29	2560.47
Furniture	16869.14	3085.82	4937.31
Paper	21377.04	3910.43	6256.69
Print.	10571.47	1933.81	3094.09
Prima.	36246.27	6630.41	10608.66
Metal	47607.09	8708.61	13933.78
Machinery	18072.26	3305.90	5289.44
Transportation	71570.05	13092.08	20947.33
TOTALS	1313748.88	240319.92	384511.87

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

	Waste Generated (tonnes)		
	Tel. Books	Glass Cont.	Plastic
Agriculture	469.46	5164.11	8919.82
Forestry	29.79	327.67	565.97
Fishing	4.56	50.13	86.60
Mining	0.00	0.00	0.00
Food	1170.48	12875.30	22239.15
Textile	68.76	756.32	1306.37
Knitting	85.50	940.55	1624.59
Wood	106.69	1173.55	2027.04
Furniture	205.72	2262.93	3908.70
Paper	260.70	2867.65	4953.22
Print.	128.92	1418.12	2449.49
Prima.	442.03	4862.30	8398.53
Metal	580.57	6386.32	11030.91
Machinery	220.39	2424.33	4187.48
Transportation	872.81	9600.86	16583.31
TOTALS	16021.33	176234.61	304405.23

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Waste Generated (tonnes)

	Alumin. Cans	Tinplate	Used Tires
Agriculture	1408.39	2347.32	7511.43
Forestry	89.36	148.94	476.61
Fishing	13.67	22.79	72.92
Mining	0.00	0.00	0.00
Food	3511.45	5852.41	18727.71
Textile	206.27	343.78	1100.10
Knitting	256.51	427.52	1368.07
Wood	320.06	533.43	1706.98
Furniture	617.16	1028.61	3291.54
Paper	782.09	1303.48	4171.13
Print.	386.76	644.60	2062.73
Prima.	1326.08	2210.14	7072.44
Metal	1741.72	2902.87	9289.19
Machinery	661.18	1101.97	3526.30
Transportation	2618.42	4364.03	13964.89
TOTALS	48063.98	80106.64	256341.24

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

	Waste Generated (tonnes)		
	Yard Waste	Food Waste	Wood Waste
Agriculture	9858.75	42721.25	126285.89
Forestry	625.55	2710.72	8012.99
Fishing	95.71	414.75	1226.01
Mining	0.00	0.00	0.00
Food	24580.12	106513.84	314859.60
Textile	1443.88	6256.81	18495.42
Knitting	1795.60	7780.92	23000.76
Wood	2240.41	9708.44	28698.56
Furniture	4320.15	18720.63	55339.02
Paper	5474.61	23723.30	70127.11
Print.	2707.33	11731.76	34679.59
Prima.	9282.58	40224.52	118905.44
Metal	12192.06	52832.25	156174.47
Machinery	4628.26	20055.80	59285.84
Transportation	18328.92	79425.30	234784.69
TOTALS	336447.88	1457940.83	4309737.17

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

Waste Generated (tonnes)

	Demol. Waste	Diapers	Foundry Sand
Agriculture	11267.14	469.46	30984.64
Forestry	714.91	29.79	1966.01
Fishing	109.38	4.56	300.81
Mining	0.00	0.00	0.00
Food	28091.56	1170.48	77251.80
Textile	1650.15	68.76	4537.91
Knitting	2052.11	85.50	5643.31
Wood	2560.47	106.69	7041.28
Furniture	4937.31	205.72	13577.60
Paper	6256.69	260.70	17205.91
Print.	3094.09	128.92	8508.75
Prima.	10608.66	442.03	29173.83
Metal	13933.78	580.57	38317.90
Machinery	5289.44	220.39	14545.97
Transportation	20947.33	872.81	57605.17
TOTALS	384511.87	16021.33	1057407.63

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

	Waste Generated (tonnes)		
	Foundry Sand	Other	TOTAL
Agriculture	30984.64	88728.75	468525.34
Forestry	1966.01	5629.95	29728.50
Fishing	300.81	861.40	4548.54
Mining	0.00	0.00	0.00
Food	77251.80	221221.05	1168140.81
Textile	4537.91	12994.92	68618.69
Knitting	5643.31	16160.38	85333.66
Wood	7041.28	20163.67	106472.73
Furniture	13577.60	38881.32	205309.80
Paper	17205.91	49271.47	260174.19
Print.	8508.75	24365.96	128662.58
Prima.	29173.83	83543.23	441143.60
Metal	38317.90	109728.53	579413.08
Machinery	14545.97	41654.36	219952.67
Transportation	57605.17	164960.25	871059.93
TOTALS	1057407.63	3028030.95	15989285.11

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

DIscharge Contaminants (tonnes)

	Amonia-N	Oil & Grease	TSS
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	1185.79	500.37	3213.32
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	1232.53	0.00	131051.09
Print.	0.00	0.00	0.00
Prima.	3672.20	3652.14	25742.17
Metal	1092.95	0.00	42753.56
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	9394.22	7120.04	245530.48

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

DIscharge Contaminants (tonnes)

	Phospurus	Cyanide	Phenolics
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	0.00	60.85	4.10
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	1068.17	0.00	0.00
Print.	0.00	0.00	0.00
Prima.	0.00	303.96	54.52
Metal	4.58	35.19	317.21
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	1408.69	411.33	382.86

Scenario 4
Substitution of $1B Plastic for Steel

Date : 09/29/1993

DIscharge Contaminants (tonnes)

	Copper	Lead	Zinc
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	64.53	5.34	55.07
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	0.00	0.00	191.64
Print.	0.00	0.00	0.00
Prima.	0.00	20.26	106.95
Métal	1.19	0.00	1644.02
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	83.59	92.42	2024.35

Scenario 4

Substitution Of $1 Billion In Sales Of Plastic For $1 Billion In Sales Of Steel

Results By Region

****************************** LINK: Ontario 2.0 ********************************
****

Impact in Eastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

Demand for Water (thousands of cubic meters)

	Intake	Discharge	Net Usage
Stormont, Dundas, Glen	7289762	7215562	74200
Prescott & Russell	4059653	4019086	40567
Ottawa-Carleton RM	144798012	143365049	1432954
Leeds & Grenville	6036338	5974519	61818
Lanark	3524459	3489358	35101
Frontenac	128711920	127438927	1272986
Lennox & Addington	2430482	2406141	24342
Hastings (Trenton SA)	7682242	7605229	77013
Prince Edward (Belleville SA)	1608969	1590998	17971
Northumberland (Cobourg SA)	4767999	4719948	48050
Peterborough	7416970	7342275	74694
Victoria	3688322	3651745	36578
Renfrew	6320044	6254909	65134
Totals	328335173	325073746	3261408

Impact in Central Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

Demand for Water (thousands of cubic meters)

	Intake	Discharge	Net Usage
Dufferin	2290401	2267508	22893
Wellington	9853931	9753658	100273
Bruce	4157235	4115911	41324
Grey	5266978	5214589	52389
Simcoe	16770107	16602989	167117
Muskoka	2809340	2781387	27953
Haliburton	818360	810274	8086
Totals	41966353	41546316	420035

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                  Demand for Water (thousands of cubic meters)

                                       Intake     Discharge     Net Usage
Hamilton                             61645917      61020790        625124
St. Cath-Niag                        12479984      12349652        130331
Haldiman-Norfolk                      6544604       6473385         71219
Brant                                 7533555       7456075         77479
Waterloo                             60576484      59972951        603530
Perth                                 4697642       4650282         47360
Oxford                                6004155       5943638         60517
Elgin                                 4945315       4895352         49962
Kent                                  7521359       7445496         75862
Essex                                49701960      49206927        495031
Lambton                               6758173       6649342        108831
Middlesex                            51438357      50922486        515868
Huron                                 3928582       3889653         38928
___________________________________________________________________________

Totals                              283776086     280876027       2900043

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                  Demand for Water (thousands of cubic meters)

                                       Intake     Discharge     Net Usage
Nipissing                             5591099       5535241         55857
Parry Sound                           2396640       2372929         23712
Manitoulin                             701674        694822          6853
Sudbury D                             3211542       3177953         33588
Sudbury RM                           16040660      15886454        154205
Timiskaming                           2818291       2791568         26723
Cochrane D                            6644778       6576329         68448
Algoma                                3784721       3747641         37080
___________________________________________________________________________

Totals                               41189406      40782936        406467
```

```
****************************** LINK: Ontario 2.0 ********************************
*********************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                  Demand for Water (thousands of cubic meters)

                                       Intake      Discharge       Net Usage
Thunder Bay                          39505711       39104158          401551
Rainy River D                         1484065        1469428           14637
Kenora D                              3875742        3833790           41952
_____________________________________________________________________________
Totals                               44865519       44407376          458140



 Impact in Greater Toronto Area

Year of Expenditure: 1991
Substitution of Plastic for Steel


                  Demand for Water (thousands of cubic meters)

                                       Intake      Discharge       Net Usage
Durham (Oshawa SA)                   22960293       22730151          230141
York                                 75641291       74890926          750360
Toronto                             516797133      511631947         5165156
Peel                                179240904      177460018         1780875
Halton                               58299200       57719685          579513
_____________________________________________________________________________
Totals                              852938820      844432726         8506044
```

```
****************************** LINK: Ontario 2.0 *****************************
********************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Stormont, Dundas, Glen                  2508           1382            247
Prescott & Russell                      1656            766             88
Ottawa-Carleton RM                     38628          11442            176
Leeds & Grenville                       2380           1551            237
Lanark                                  1035            420             38
Frontenac                              34156           9819            319
Lennox & Addington                       871            407            158
Hastings (Trenton SA)                   2171            739             51
Prince Edward (Belleville SA)           3714           2392            102
Northumberland (Cobourg SA)             1633            711             80
Peterborough                            2493           1102            120
Victoria                                1141            402             18
Renfrew                                 1997            772             50
-----------------------------------------------------------------------------
Totals                                 94385          31905           1682


 Impact in Central Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Dufferin                                 766            333             25
Wellington                              3590           1733            224
Bruce                                   1162            400             30
Grey                                    1732            643             36
Simcoe                                  4683           1704            199
Muskoka                                  793            261             17
Haliburton                               215             60              1
-----------------------------------------------------------------------------
Totals                                 12940           5133            533
```

```
****************************** LINK: Ontario 2.0 ******************************
**************************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Hamilton                               27707          13312             1933
St. Cath-Niag                           9038           4595              587
Haldiman-Norfolk                        4055           2385              373
Brant                                   3751           1712              272
Waterloo                               17358           6012              530
Perth                                   1373            528              103
Oxford                                  2712           1307              161
Elgin                                   1601            645               70
Kent                                    3195           1455               82
Essex                                  14942           5422              304
Lambton                                51105          21625             3687
Middlesex                              15183           5689              363
Huron                                   1121            396               26
____________________________________________________________________________
Totals                                153140          65082             8490


 Impact in Northeastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Nipissing                               1661            681               64
Parry Sound                              634            182                6
Manitoulin                               185             52                1
Sudbury D                                968            335               19
Sudbury RM                              4612           1743               81
Timiskaming                              770            248               12
Cochrane D                              2030            730               23
Algoma                                  3055           1953              430
____________________________________________________________________________
Totals                                 13913           5923              635
```

```
****************************** LINK: Ontario 2.0 ******************************
******************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Thunder Bay                            11093           3453             72
Rainy River D                            390            109              1
Kenora D                                1359            552             41
----------------------------------------------------------------------------
Totals                                 12843           4115            115



 Impact in Greater Toronto Area

Year of Expenditure: 1991
Substitution of Plastic for Steel


                                       Air Emissions (tonnes)

                              Sulphur Oxides Nitrogen Oxide   Volatile Org C
Durham (Oshawa SA)                      7679           3000            148
York                                   21056           6706            251
Toronto                               162705          55500           3491
Peel                                   50275          16361            616
Halton                                 16840           5484            215
----------------------------------------------------------------------------
Totals                                258555          87051           4722
```

```
****************************** LINK: Ontario 2.0 *******************************
********************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                              Energy Used (terajoules)

                                          Coal      Crude Oil    Natural Gas
Stormont, Dundas, Glen                    4899              0          12412
Prescott & Russell                        3666              0           6194
Ottawa-Carleton RM                       43938            100         124824
Leeds & Grenville                         7729            453          14585
Lanark                                    2100              0           5163
Frontenac                                 7295              0          15777
Lennox & Addington                        1261              0           3871
Hastings (Trenton SA)                     4236              0          10795
Prince Edward (Belleville SA)             4095              0           4323
Northumberland (Cobourg SA)               4377           1238           6658
Peterborough                              5408              0           8965
Victoria                                  1702              0           2697
Renfrew                                   6213              0          13142
--------------------------------------------------------------------------------
Totals                                   96921           1791         229406


                                   Electricity  Nuclear Steam          TOTAL
Stormont, Dundas, Glen                       3              1             21
Prescott & Russell                           2              0             12
Ottawa-Carleton RM                          36              3            208
Leeds & Grenville                            3              1             27
Lanark                                       1              0              9
Frontenac                                    4              0             28
Lennox & Addington                           1              0              6
Hastings (Trenton SA)                        3              0             18
Prince Edward (Belleville SA)                1              0              9
Northumberland (Cobourg SA)                  2              0             14
Peterborough                                 2              0             17
Victoria                                     1              0              5
Renfrew                                      4              0             23
--------------------------------------------------------------------------------
Totals                                      63              7            398
```

Impact in Central Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

Energy Used (terajoules)

	Coal	Crude Oil	Natural Gas
Dufferin	1074	0	2290
Wellington	7306	6385	16634
Bruce	1476	0	4163
Grey	2264	62	4847
Simcoe	6630	0	21051
Muskoka	1022	0	2906
Haliburton	207	0	591
Totals	19979	6447	52482

	Electricity	Nuclear Steam	TOTAL
Dufferin	1	0	4
Wellington	4	1	35
Bruce	1	0	7
Grey	1	0	9
Simcoe	5	1	34
Muskoka	1	0	5
Haliburton	0	0	1
Totals	13	3	95

```
****************************** LINK: Ontario 2.0 ********************************
*********************************************************************************

 Impact in Southwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                             Energy Used (terajoules)

                                          Coal      Crude Oil     Natural Gas
Hamilton                                115200         71029         79335
St. Cath-Niag                            27033         66771         40195
Haldiman-Norfolk                         25646             0         19711
Brant                                     4439         29219         12003
Waterloo                                 13981          4329         35558
Perth                                     2330             0          6592
Oxford                                    5250           438          8014
Elgin                                     4599             0         11450
Kent                                      6208             0         11336
Essex                                    18279          1082         42810
Lambton                                  14153       1185885         53120
Middlesex                                22170             0         39965
Huron                                     2370             0          4554
------------------------------------------------------------------------------
Totals                                  261658       1358752        364643


                                   Electricity  Nuclear Steam           TOTAL
Hamilton                                    18              3             287
St. Cath-Niag                               10              2             146
Haldiman-Norfolk                             5              1              51
Brant                                        3              1              49
Waterloo                                     8              1              64
Perth                                        2              0              11
Oxford                                       2              0              16
Elgin                                        2              0              19
Kent                                         3              0              21
Essex                                        9              1              73
Lambton                                     11             11            1275
Middlesex                                   10              2              74
Huron                                        2              0               9
------------------------------------------------------------------------------
Totals                                      85             24            2094
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                             Energy Used (terajoules)

                                          Coal      Crude Oil    Natural Gas
Nipissing                                 3293              0           8354
Parry Sound                                690              0           1899
Manitoulin                                 240              0            575
Sudbury D                                 1874              0           4829
Sudbury RM                               10342              0          19291
Timiskaming                               1825              0           3189
Cochrane D                                4615              0          11506
Algoma                                   35322            136          20226
-----------------------------------------------------------------------------
Totals                                   58202            136          69868

                                   Electricity  Nuclear Steam          TOTAL
Nipissing                                    2              0             14
Parry Sound                                  1              0              3
Manitoulin                                   0              0              1
Sudbury D                                    1              0              8
Sudbury RM                                   6              1             36
Timiskaming                                  1              0              6
Cochrane D                                   3              0             20
Algoma                                       5              0             61
-----------------------------------------------------------------------------
Totals                                      20              1            150
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                             Energy Used (terajoules)

                                          Coal       Crude Oil     Natural Gas
Thunder Bay                               9973               0           26882
Rainy River D                              491               0            1339
Kenora D                                  5409               0           11045
------------------------------------------------------------------------------
Totals                                   15872               0           39267

                                   Electricity  Nuclear Steam            TOTAL
Thunder Bay                                  8               0              45
Rainy River D                                0               0               2
Kenora D                                     3               0              20
------------------------------------------------------------------------------
Totals                                      11               0              67


 Impact in Greater Toronto Area

Year of Expenditure: 1991
Substitution of Plastic for Steel


                             Energy Used (terajoules)

                                          Coal       Crude Oil     Natural Gas
Durham (Oshawa SA)                       15676            3043           48161
York                                     15661             760           36831
Toronto                                 112465          421017          300475
Peel                                     26235           17762           71715
Halton                                   13767            8277           38471
------------------------------------------------------------------------------
Totals                                  183804          450859          495653

                                   Electricity  Nuclear Steam            TOTAL
Durham (Oshawa SA)                          10               1              78
York                                        10               1              65
Toronto                                     77              13             924
Peel                                        18               3             137
Halton                                      10               1              71
------------------------------------------------------------------------------
Totals                                     126              20            1276
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Eastern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Waste Generated (tonnes)

                                       ONP      Fine Paper         Boxboard
Stormont, Dundas, Glen                5437           11384            10534
Prescott & Russell                    2264            4741             4387
Ottawa-Carleton RM                   29280           61305            56730
Leeds & Grenville                     4327            9060             8384
Lanark                                1729            3619             3349
Frontenac                             7290           15264            14125
Lennox & Addington                    1337            2800             2591
Hastings (Trenton SA)                 3318            6946             6428
Prince Edward (Belleville SA)         2259            4729             4376
Northumberland (Cobourg SA)           2865            5998             5551
Peterborough                          3839            8038             7438
Victoria                              1634            3422             3167
Renfrew                               2745            5747             5318
___________________________________________________________________________

Totals                               68323          143052           132377

                                       OCC     Mixed Paper        Magazines
Stormont, Dundas, Glen               13932            2549             4078
Prescott & Russell                    5802            1061             1698
Ottawa-Carleton RM                   75030           13725            21960
Leeds & Grenville                    11088            2028             3245
Lanark                                4430             810             1297
Frontenac                            18681            3417             5468
Lennox & Addington                    3426             627             1003
Hastings (Trenton SA)                 8502            1555             2488
Prince Edward (Belleville SA)         5788            1059             1694
Northumberland (Cobourg SA)           7341            1343             2149
Peterborough                          9837            1799             2879
Victoria                              4188             766             1226
Renfrew                               7033            1287             2058
___________________________________________________________________________

Totals                              175079           32027            51243

                                Tel. Books     Glass Cont.          Plastic
Stormont, Dundas, Glen                 170            1869             3228
Prescott & Russell                      71             778             1344
Ottawa-Carleton RM                     915           10065            17385
Leeds & Grenville                      135            1487             2569
Lanark                                  54             594             1026
Frontenac                              228            2506             4329
Lennox & Addington                      42             460              794
Hastings (Trenton SA)                  104            1140             1970
Prince Edward (Belleville SA)           71             776             1341
Northumberland (Cobourg SA)             90             985             1701
Peterborough                           120            1320             2279
Victoria                                51             562              970
Renfrew                                 86             943             1630
___________________________________________________________________________

Totals                                2135           23486            40567
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Eastern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Waste Generated (tonnes)

                               Alumin. Cans         Tinplate        Used Tires
Stormont, Dundas, Glen                  510              850              2718
Prescott & Russell                      212              354              1132
Ottawa-Carleton RM                     2745             4575             14640
Leeds & Grenville                       406              676              2163
Lanark                                  162              270               864
Frontenac                               683             1139              3645
Lennox & Addington                      125              209               669
Hastings (Trenton SA)                   311              518              1659
Prince Edward (Belleville SA)           212              353              1129
Northumberland (Cobourg SA)             269              448              1432
Peterborough                            360              600              1919
Victoria                                153              255               817
Renfrew                                 257              429              1372
------------------------------------------------------------------------------
Totals                                 6405            10676             34162

                                 Yard Waste       Food Waste        Wood Waste
Stormont, Dundas, Glen                 3568            15461             45704
Prescott & Russell                     1486             6439             19034
Ottawa-Carleton RM                    19215            83265            246135
Leeds & Grenville                      2840            12305             36374
Lanark                                 1134             4916             14532
Frontenac                              4784            20731             61283
Lennox & Addington                      877             3802             11240
Hastings (Trenton SA)                  2177             9435             27889
Prince Edward (Belleville SA)          1482             6423             18988
Northumberland (Cobourg SA)            1880             8147             24083
Peterborough                           2519            10917             32270
Victoria                               1073             4648             13740
Renfrew                                1801             7805             23072
------------------------------------------------------------------------------
Totals                                44837           194295            574344

                               Demol. Waste          Diapers      Foundry Sand
Stormont, Dundas, Glen                 4078              170             11214
Prescott & Russell                     1698               71              4670
Ottawa-Carleton RM                    21960              915             60390
Leeds & Grenville                      3245              135              8924
Lanark                                 1297               54              3565
Frontenac                              5468              228             15036
Lennox & Addington                     1003               42              2758
Hastings (Trenton SA)                  2488              104              6843
Prince Edward (Belleville SA)          1694               71              4659
Northumberland (Cobourg SA)            2149               90              5909
Peterborough                           2879              120              7918
Victoria                               1226               51              3371
Renfrew                                2058               86              5661
------------------------------------------------------------------------------
Totals                                51243             2135            140917
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Eastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel


                            Waste Generated (tonnes)

                                     Other          TOTAL
Stormont, Dundas, Glen               32112         169563
Prescott & Russell                   13373          70618
Ottawa-Carleton RM                  172935         913172
Leeds & Grenville                    25556         134947
Lanark                               10210          53914
Frontenac                            43058         227363
Lennox & Addington                    7897          41701
Hastings (Trenton SA)                19595         103470
Prince.Edward (Belleville SA)        13341          70446
Northumberland (Cobourg SA)          16921          89350
Peterborough                         22673         119723
Victoria                              9653          50974
Renfrew                              16210          85598
-----------------------------------------------------------------------------
Totals                              403536        2130839
```

```
****************************** LINK: Ontario 2.0 ******************************
****************************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                              Waste Generated (tonnes)

                                        ONP       Fine Paper            Boxboard
Dufferin                                 1276            2672             2473
Wellington                               7439           15575            14412
Bruce                                    2732            5721             5294
Grey                                     2937            6150             5691
Simcoe                                   9364           19607            18143
Muskoka                                  1664            3484             3224
Haliburton                                362             758              701
-----------------------------------------------------------------------------
Totals                                  25775           53966            49939

                                        OCC      Mixed Paper           Magazines
Dufferin                                 3271             598              957
Wellington                              19062            3487             5579
Bruce                                    7002            1281             2049
Grey                                     7527            1377             2203
Simcoe                                  23996            4390             7023
Muskoka                                  4264             780             1248
Haliburton                                928             170              271
-----------------------------------------------------------------------------
Totals                                  66048           12082            19331

                                 Tel. Books      Glass Cont.             Plastic
Dufferin                                   40             439              758
Wellington                                232            2557             4417
Bruce                                      85             939             1622
Grey                                       92            1010             1744
Simcoe                                    293            3219             5560
Muskoka                                    52             572              988
Haliburton                                 11             124              215
-----------------------------------------------------------------------------
Totals                                    805            8860            15304

                              Alumin. Cans          Tinplate         Used Tires
Dufferin                                  120             199              638
Wellington                                697            1162             3719
Bruce                                     256             427             1366
Grey                                      275             459             1469
Simcoe                                    878            1463             4682
Muskoka                                   156             260              832
Haliburton                                 34              57              181
-----------------------------------------------------------------------------
Totals                                   2416            4027            12887
```

```
****************************** LINK: Ontario 2.0 ********************************
**********************************************************************************

 Impact in Central Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Waste Generated (tonnes)

                                 Yard Waste        Food Waste        Wood Waste
Dufferin                                838              3630             10729
Wellington                             4882             21154             62531
Bruce                                  1793              7770             22969
Grey                                   1928              8353             24691
Simcoe                                 6145             26630             78719
Muskoka                                1092              4732             13987
Haliburton                              238              1029              3043
_______________________________________________________________________________
Totals                                16915             73297            216670


                               Demol. Waste          Diapers     Foundry Sand
Dufferin                                957                40              2632
Wellington                             5579               232             15342
Bruce                                  2049                85              5636
Grey                                   2203                92              6058
Simcoe                                 7023               293             19314
Muskoka                                1248                52              3432
Haliburton                              271                11               747
_______________________________________________________________________________
Totals                                19331               805             53161


                                      Other             TOTAL
Dufferin                               7538             39806
Wellington                            43935            231994
Bruce                                 16138             85216
Grey                                  17348             91605
Simcoe                                55308            292051
Muskoka                                9827             51891
Haliburton                             2138             11289
_______________________________________________________________________________
Totals                               152233            803852
```

```
****************************** LINK: Ontario 2.0 ******************************
******************************************************************************

 Impact in Southwestern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Waste Generated (tonnes)

                                       ONP      Fine Paper          Boxboard
Hamilton                             28852           60410             55902
St. Cath-Niag                        17814           37299             34516
Haldiman-Norfolk                      5955           12468             11538
Brant                                 4267            8933              8266
Waterloo                             21125           44231             40930
Perth                                 4012            8401              7774
Oxford                                4161            8712              8062
Elgin                                 4361            9130              8449
Kent                                  5029           10530              9744
Essex                                17722           37106             34337
Lambton                               8417           17622             16307
Middlesex                            17808           37286             34503
Huron                                 2794            5850              5413
----------------------------------------------------------------------------
Totals                              142318          297977            275740

                                       OCC     Mixed Paper         Magazines
Hamilton                             73934           13525             21639
St. Cath-Niag                        45650            8351             13361
Haldiman-Norfolk                     15259            2791              4466
Brant                                10933            2000              3200
Waterloo                             54134            9902             15844
Perth                                10281            1881              3009
Oxford                               10662            1950              3121
Elgin                                11174            2044              3270
Kent                                 12888            2357              3772
Essex                                45414            8307             13292
Lambton                              21567            3945              6312
Middlesex                            45633            8348             13356
Huron                                 7159            1310              2095
----------------------------------------------------------------------------
Totals                              364689           66711            106738

                                Tel. Books     Glass Cont.           Plastic
Hamilton                               902            9918             17131
St. Cath-Niag                          557            6124             10577
Haldiman-Norfolk                       186            2047              3536
Brant                                  133            1467              2533
Waterloo                               660            7262             12543
Perth                                  125            1379              2382
Oxford                                 130            1430              2471
Elgin                                  136            1499              2589
Kent                                   157            1729              2986
Essex                                  554            6092             10523
Lambton                                263            2893              4997
Middlesex                              557            6122             10574
Huron                                   87             960              1659
----------------------------------------------------------------------------
Totals                                4447           48922             84501
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Waste Generated (tonnes)

                              Alumin. Cans          Tinplate        Used Tires
Hamilton                              2705              4508             14426
St. Cath-Niag                         1670              2784              8907
Haldiman-Norfolk                       558               930              2977
Brant                                  400               667              2133
Waterloo                              1980              3301             10563
Perth                                  376               627              2006
Oxford                                 390               650              2080
Elgin                                  409               681              2180
Kent                                   471               786              2515
Essex                                 1661              2769              8861
Lambton                                789              1315              4208
Middlesex                             1670              2783              8904
Huron                                  262               437              1397
_____________________________________________________________________________

Totals                               13342             22237             71159

                                Yard Waste        Food Waste        Wood Waste
Hamilton                             18934             82049            242540
St. Cath-Niag                        11691             50660            149753
Haldiman-Norfolk                      3908             16934             50058
Brant                                 2800             12133             35866
Waterloo                             13863             60075            177585
Perth                                 2633             11410             33728
Oxford                                2731             11833             34978
Elgin                                 2862             12400             36656
Kent                                  3300             14302             42277
Essex                                11630             50398            148979
Lambton                               5523             23935             70751
Middlesex                            11687             50642            149700
Huron                                 1833              7945             23486
_____________________________________________________________________________

Totals                               93396            404715           1196356

                              Demol. Waste           Diapers      Foundry Sand
Hamilton                             21639               902             59508
St. Cath-Niag                        13361               557             36742
Haldiman-Norfolk                      4466               186             12282
Brant                                 3200               133              8800
Waterloo                             15844               660             43571
Perth                                 3009               125              8275
Oxford                                3121               130              8582
Elgin                                 3270               136              8994
Kent                                  3772               157             10373
Essex                                13292               554             36553
Lambton                               6312               263             17359
Middlesex                            13356               557             36729
Huron                                 2095                87              5762
_____________________________________________________________________________

Totals                              106738              4447            293530
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                            Waste Generated (tonnes)

                                     Other            TOTAL
Hamilton                              170409          899834
St. Cath-Niag                         105217          555589
Haldiman-Norfolk                       35171          185718
Brant                                  25199          133063
Waterloo                              124771          658846
Perth                                  23697          125131
Oxford                                 24575          129769
Elgin                                  25754          135994
Kent                                   29704          156851
Essex                                 104673          552719
Lambton                                49710          262491
Middlesex                             105179          555391
Huron                                  16501           87133
----------------------------------------------------------------------------
Totals                                840563         4438527
```

```
******************************** LINK: Ontario 2.0 ********************************
***********************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Waste Generated (tonnes)

                                        ONP      Fine Paper           Boxboard
Nipissing                              2092            4379               4053
Parry Sound                             959            2008               1858
Manitoulin                              213             447                413
Sudbury D                              1167            2443               2260
Sudbury RM                             5689           11910              11022
Timiskaming                            1181            2472               2288
Cochrane D                             2724            5703               5278
Algoma                                 5250           10992              10172
------------------------------------------------------------------------------
Totals,                               19274           40355              37343

                                        OCC     Mixed Paper          Magazines
Nipissing                              5360             980               1569
Parry Sound                            2457             449                719
Manitoulin                              547             100                160
Sudbury D                              2989             547                875
Sudbury RM                            14577            2667               4266
Timiskaming                            3026             554                886
Cochrane D                             6980            1277               2043
Algoma                                13453            2461               3938
------------------------------------------------------------------------------
Totals                                49390            9035              14455

                                 Tel. Books     Glass Cont.            Plastic
Nipissing                                65             719               1242
Parry Sound                              30             330                569
Manitoulin                                7              73                127
Sudbury D                                36             401                693
Sudbury RM                              178            1955               3378
Timiskaming                              37             406                701
Cochrane D                               85             936               1617
Algoma                                  164            1805               3117
------------------------------------------------------------------------------
Totals                                  602            6625              11444

                               Alumin. Cans        Tinplate         Used Tires
Nipissing                               196             327               1046
Parry Sound                              90             150                479
Manitoulin                               20              33                107
Sudbury D                               109             182                583
Sudbury RM                              533             889               2844
Timiskaming                             111             185                590
Cochrane D                              255             426               1362
Algoma                                  492             820               2625
------------------------------------------------------------------------------
Totals                                 1807            3012               9637
```

```
******************************* LINK: Ontario 2.0 ********************************
**********************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                              Waste Generated (tonnes)

                                 Yard Waste        Food Waste        Wood Waste
Nipissing                              1373              5948             17583
Parry Sound                             629              2727              8060
Manitoulin                              140               607              1793
Sudbury D                               766              3318              9807
Sudbury RM                             3733             16177             47819
Timiskaming                             775              3358              9927
Cochrane D                             1788              7746             22899
Algoma                                 3445             14930             44134
______________________________________________________________________________
Totals                                12649             54810            162022

                               Demol. Waste           Diapers     Foundry Sand
Nipissing                              1569                65              4314
Parry Sound                             719                30              1978
Manitoulin                              160                 7               440
Sudbury D                               875                36              2406
Sudbury RM                             4266               178             11733
Timiskaming                             886                37              2436
Cochrane D                             2043                85              5618
Algoma                                 3938               164             10828
______________________________________________________________________________
Totals                                14455               602             39753

                                      Other             TOTAL
Nipissing                             12354             65234
Parry Sound                            5663             29904
Manitoulin                             1260              6652
Sudbury D                              6890             36384
Sudbury RM                            33598            177411
Timiskaming                            6975             36829
Cochrane D                            16089             84956
Algoma                                31008            163737
______________________________________________________________________________
Totals                               113837            601108
```

```
****************************** LINK: Ontario 2.0 ******************************
******************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                            Waste Generated (tonnes)

                                      ONP      Fine Paper          Boxboard
Thunder Bay                          6856           14355             13284
Rainy River D                         474             993               918
Kenora D                             1877            3930              3637
-----------------------------------------------------------------------------
Totals                               9207           19278             17839

                                      OCC     Mixed Paper         Magazines
Thunder Bay                         17569            3214              5142
Rainy River D                        1215             222               356
Kenora.D                             4810             880              1408
-----------------------------------------------------------------------------
Totals                              23594            4316              6905

                               Tel. Books     Glass Cont.           Plastic
Thunder Bay                           214            2357              4071
Rainy River D                          15             163               281
Kenora D                               59             645              1114
-----------------------------------------------------------------------------
Totals                                288            3165              5467

                             Alumin. Cans       Tinplate         Used Tires
Thunder Bay                           643            1071              3428
Rainy River D                          44              74               237
Kenora D                              176             293               938
-----------------------------------------------------------------------------
Totals                                863            1439              4604

                               Yard Waste      Food Waste        Wood Waste
Thunder Bay                          4499           19498             57636
Rainy River D                         311            1348              3985
Kenora D                             1232            5337             15778
-----------------------------------------------------------------------------
Totals                               6042           26183             77399

                             Demol. Waste         Diapers      Foundry Sand
Thunder Bay                          5142             214             14141
Rainy River D                         356              15               978
Kenora D                             1408              59              3871
-----------------------------------------------------------------------------
Totals                               6905             288             18990

                                    Other           TOTAL
Thunder Bay                         40495          213832
Rainy River D                        2800           14785
Kenora D                            11086           58536
-----------------------------------------------------------------------------
Totals                              54381          287153
```

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Greater Toronto Area

Year of Expenditure: 1991
Substitution of Plastic for Steel

                            Waste Generated (tonnes)

                                        ONP       Fine Paper          Boxboard
Durham (Oshawa SA)                    16704          34973          32363
York                                  22104          46281          42827
Toronto                              155129         324802         300563
Peel                                  36028          75434          69805
Halton                                17867          37409          34617
------------------------------------------------------------------------------
Totals                               247832         518899         480175


                                        OCC      Mixed Paper         Magazines
Durham (Oshawa SA)                    42803           7830          12528
York                                  56643          10361          16578
Toronto                              397519          72717         116347
Peel                                  92322          16888          27021
Halton                                45784           8375          13400
------------------------------------------------------------------------------
Totals                               635071         116171         185874


                                 Tel. Books      Glass Cont.           Plastic
Durham (Oshawa SA)                      522           5742           9918
York                                    691           7598          13125
Toronto                                4848          53326          92108
Peel                                   1126          12385          21392
Halton                                  558           6142          10608
------------------------------------------------------------------------------
Totals                                 7745          85192         147150


                               Alumin. Cans         Tinplate        Used Tires
Durham (Oshawa SA)                     1566           2610           8352
York                                   2072           3454          11052
Toronto                               14543          24239          77565
Peel                                   3378           5629          18014
Halton                                 1675           2792           8933
------------------------------------------------------------------------------
Totals                                23234          38724         123916


                                 Yard Waste       Food Waste        Wood Waste
Durham (Oshawa SA)                    10962          47501         140415
York                                  14506          62859         185815
Toronto                              101804         441149        1304055
Peel                                  23644         102455         302862
Halton                                11725          50809         150193
------------------------------------------------------------------------------
Totals                               162640         704773        2083341
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Greater Toronto Area

Year of Expenditure: 1991
Substitution of Plastic for Steel

                              Waste Generated (tonnes)

                              Demol. Waste           Diapers     Foundry Sand
Durham (Oshawa SA)                      12528            522            34451
York                                    16578            691            45590
Toronto                                116347           4848           319954
Peel                                    27021           1126            74308
Halton                                  13400            558            36850
-----------------------------------------------------------------------------
Totals                                 185874           7745           511154


                                     Other             TOTAL
Durham (Oshawa SA)                      98656         520946
York                                   130554         689382
Toronto                                916232        4838093
Peel                                   212792        1123629
Halton                                 105526         557223
-----------------------------------------------------------------------------
Totals                                1463760        7729273
```

```
****************************** LINK: Ontario 2.0 ********************************
**********************************************************************************

Impact in Eastern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                             Contaminants (tonnes)

                                    Ammonia-N      Oil & Grease   TSS
Stormont, Dundas, Glen                     76               60           1280
Prescott & Russell                         33               53            885
Ottawa-Carleton RM                         95               69           2064
Leeds & Grenville                         145              112           2608
Lanark                                     27               16            409
Frontenac                                  43               38            909
Lennox & Addington                          8                8            654
Hastings (Trenton SA)                      33               18           1349
Prince Edward (Belleville SA)              24              215           3532
Northumberland (Cobourg SA)                56               50            818
Peterborough                               83               71           1951
Victoria                                   16               20            271
Renfrew                                    86               39           5051
-----------------------------------------------------------------------------
Totals                                    724              769          21781

                                    Phosphorus     Cyanide        Phenolics
Stormont, Dundas, Glen                      8                2              3
Prescott & Russell                          2                2              1
Ottawa-Carleton RM                         14                3              3
Leeds & Grenville                          19                6              3
Lanark                                      2                1              2
Frontenac                                   3                3              2
Lennox & Addington                          4                0              0
Hastings (Trenton SA)                      10                1              1
Prince Edward (Belleville SA)               2                2              1
Northumberland (Cobourg SA)                 3                3              2
Peterborough                               11                4              2
Victoria                                    0                1              0
Renfrew                                    39                3              1
-----------------------------------------------------------------------------
Totals                                    118               32             22

                                    Copper         Lead           Zinc
Stormont, Dundas, Glen                      1                1             14
Prescott & Russell                          0                0              4
Ottawa-Carleton RM                          1                2             19
Leeds & Grenville                           1                2             16
Lanark                                      0                0              9
Frontenac                                   0                0             11
Lennox & Addington                          0                0              2
Hastings (Trenton SA)                       0                0              5
Prince Edward (Belleville SA)               0                0              5
Northumberland (Cobourg SA)                 0                1              8
Peterborough                                1                1             12
Victoria                                    0                0              2
Renfrew                                     0                0              9
-----------------------------------------------------------------------------
Totals                                      5                8            117
```

****************************** LINK: Ontario 2.0 ******************************
****

Impact in Central Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

Contaminants (tonnes)

	Ammonia-N	Oil & Grease	TSS
Dufferin	17	16	362
Wellington	123	88	2924
Bruce	32	5	1013
Grey	17	28	547
Simcoe	61	24	1106
Muskoka	13	5	366
Haliburton	1	0	3
Totals	265	166	6320

	Phosphorus	Cyanide	Phenolics
Dufferin	1	1	1
Wellington	14	5	8
Bruce	1	1	7
Grey	0	1	1
Simcoe	3	2	6
Muskoka	0	1	2
Haliburton	0	0	0
Totals	20	10	26

	Copper	Lead	Zinc
Dufferin	0	0	4
Wellington	1	2	42
Bruce	0	0	37
Grey	0	0	6
Simcoe	1	1	33
Muskoka	0	0	12
Haliburton	0	0	0
Totals	3	3	135

```
****************************** LINK: Ontario 2.0 ******************************
*******************************************************************************

 Impact in Southwestern Ontario
Year of Expenditure: 1991
Substitution of Plastic for Steel

                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Hamilton                                1777           1656          21189
St. Cath-Niag                            378            377           7856
Haldiman-Norfolk                         422            359          11720
Brant                                     92             61           3324
Waterloo                                 188            114           4874
Perth                                     25              8            841
Oxford                                    58             92           1857
Elgin                                     47             28           1537
Kent                                      76             97           2835
Essex                                    221            181           4985
Lambton                                  704            582           7610
Middlesex                                324            225          10525
Huron                                     32             19            357
---------------------------------------------------------------------------
Totals                                  4342           3798          79510

                                   Phosphorus     Cyanide        Phenolics
Hamilton                                  47            127             59
St. Cath-Niag                             27             21             19
Haldiman-Norfolk                          68             26             10
Brant                                     23              2              4
Waterloo                                  14              7             22
Perth                                      3              1              3
Oxford                                     3              4              4
Elgin                                      9              2              3
Kent                                       7              4              7
Essex                                     18             11             15
Lambton                                   97              5              5
Middlesex                                 76             14              7
Huron                                      1              2              1
---------------------------------------------------------------------------
Totals                                   393            225            159

                                   Copper         Lead           Zinc
Hamilton                                   2             12            242
St. Cath-Niag                              1              3             91
Haldiman-Norfolk                           1              2             48
Brant                                      1              1             23
Waterloo                                   1              2            114
Perth                                      0              0             18
Oxford                                     0              0             19
Elgin                                      0              0             14
Kent                                       0              0             37
Essex                                      2              2             74
Lambton                                    6             20             21
Middlesex                                  1              3             41
Huron                                      1              0              6
---------------------------------------------------------------------------
Totals                                    17             48            749
```

```
********************************* LINK: Ontario 2.0 ******************************
**********************************************************************************

 Impact in Northeastern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                                 Contaminants (tonnes)

                                        Ammonia-N        Oil & Grease   TSS
Nipissing                                      50                  28            1356
Parry Sound                                     3                   1              26
Manitoulin                                      4                   2              12
Sudbury D                                      66                  10            4459
Sudbury RM                                    362                 177            2673
Timiskaming                                    75                  34             251
Cochrane D                                    173                  42            8799
Algoma                                        634                 523            4981
-------------------------------------------------------------------------------------
Totals                                       1367                 819           22557


                                        Phosphorus       Cyanide            Phenolics
Nipissing                                      11                   2               1
Parry Sound                                     0                   0               0
Manitoulin                                      0                   0               0
Sudbury D                                      36                   1               0
Sudbury RM                                     14                  18               3
Timiskaming                                     0                   4               0
Cochrane D                                     69                   5               1
Algoma                                         10                  46               8
-------------------------------------------------------------------------------------
Totals                                        139                  75              13


                                        Copper           Lead             Zinc
Nipissing                                       1                   1               4
Parry Sound                                     0                   0               1
Manitoulin                                      0                   0               0
Sudbury D                                       1                   0               8
Sudbury RM                                     16                   2              24
Timiskaming                                     4                   0               4
Cochrane D                                      5                   0              18
Algoma                                          9                   3              27
-------------------------------------------------------------------------------------
Totals                                         37                   7              85
```

```
****************************** LINK: Ontario 2.0 *******************************
********************************************************************************

 Impact in Northwestern Ontario

Year of Expenditure: 1991
Substitution of Plastic for Steel

                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease   TSS
Thunder Bay                               282             29     23648
Rainy River D                               2              1         5
Kenora D                                  149             41      8859
---------------------------------------------------------------------------
Totals                                    432             71     32512


                                   Phosphorus     Cyanide        Phenolics
Thunder Bay                               190              3         1
Rainy River D                               0              0         0
Kenora D                                   70              4         0
---------------------------------------------------------------------------
Totals                                    260              7         2


                                   Copper         Lead           Zinc
Thunder Bay                                 3              0        41
Rainy River D                               0              0         0
Kenora D                                    3              0        15
---------------------------------------------------------------------------
Totals                                      6              1        57
```

```
****************************** LINK: Ontario 2.0 ******************************
********************************************************************************

 Impact in Greater Toronto Area

Year of Expenditure: 1991
Substitution of Plastic for Steel


                            Contaminants (tonnes)

                                   Ammonia-N      Oil & Grease    TSS
Durham (Oshawa SA)                       103             94            3615
York                                     141            115            3883
Toronto                                 1532            970           58053
Peel                                     352            229           12468
Halton                                   133             87            4918
-----------------------------------------------------------------------------
Totals                                  2261           1495           82936


                                   Phosphorus     Cyanide         Phenolics
Durham (Oshawa SA)                        18              5               5
York                                      16              6              11
Toronto                                  347             39             109
Peel                                      75              8              24
Halton                                    24              5              11
-----------------------------------------------------------------------------
Totals                                   480             62             160


                                   Copper         Lead            Zinc
Durham (Oshawa SA)                         1              1              29
York                                       1              1              55
Toronto                                   10             18             601
Peel                                       2              5             132
Halton                                     2              1              60
-----------------------------------------------------------------------------
Totals                                    16             26             876
```

Scenario 5 Contaminants Reductions In Pulp And Paper Industry Results By Sector

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Provincial Impact

(Millions)

	Direct	Indirect & Induced	Total
Gross Domestic Product	205501.33	73520.59	279021.92
Gross Sales	168444.30	294034.34	462478.64
Labour Income	42365.10	110551.40	152916.50
Employment (Person Years)	1510830	3110408	4621238

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Taxes

(Millions)

	Federal	Provincial	Local	Total
Personal Tax	18017.73	8478.93	0.00	26496.66
Indirect Business Tax	0.00	11352.62	0.00	11352.62
Tariffs	4752.39	0.00	0.00	4752.39
Corporate Profit Tax	6414.29	3159.28	0.00	9573.56
Property & Business Tax	0.00	0.00	9827.64	9827.64
Goods & Services Tax	14708.16	0.00	0.00	14708.16
Total Taxes	43892.57	22990.83	9827.64	76711.04

Date : 09/29/1993

Employment by Industry

(Person Years)

Agriculture	197994.65	Forestry	12579.00
Fishing	1927.94	Mining	32502.75
Food	107014.51	Textile	54065.03
Knitting	67538.17	Wood	42072.37
Furniture	35198.20	Paper	63539.99
Print.	82976.30	Prima.	87961.34
Metal	118993.71	Machinery	137230.69
Transportation	230947.78	Electrical P.	116822.89
Non-Metal.	29607.21	Petroleum P.	16454.00
Chemical P.	62177.54	Other	167294.79
Construction	264988.25	Utilities	369871.82
Trade	1159151.38	Services	1162327.59
TOTAL	4621237.92		

```
Scenario 5                                                    Date : 09/29/1993
 Contaminant Reduction in Pulp and Paper
                                   Industry Output
                                   ---------------
                                   (Millions)

 Agriculture              7764.87    Forestry                    1000.49
 Fishing                    91.00    Mining                      2604.20
 Food                    19707.34    Textile                     5398.23
 Knitting                 2870.83    Wood                        2468.31
 Furniture                2888.45    Paper                       9640.36
 Print.                   7744.74    Prima.                     15813.02
 Metal                   13619.34    Machinery                  17851.92
 Transportation          56187.70    Electrical P.              11895.11
 Non-Metal.               4983.06    Petroleum P.               13329.46
 Chemical P.             15199.20    Other                      15919.32
 Construction            29563.48    Utilities                  39850.20
 Trade                   73792.00    Travel & Accom.            74341.27
 Housing                 17954.74    TOTAL                     462478.64
```

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Demand for Water (thousands of cubic metres)

	Intake	Discharge	Difference
Agriculture	0	0	0
Forestry	0	0	0
Fishing	0	0	0
Mining	160859	183301	-22442
Food	260723	233607	27116
Textile	364647	361256	3391
Knitting	0	0	0
Wood	30506	28475	2031
Furniture	0	0	0
Paper	1285967	1206634	79333
Print.	0	0	0
Prima.	1644182	1606960	37223
Metal	66884	63984	2900
Machinery	0	0	0
Transportation	183366	177373	5993
TOTALS	1601802061	1585763520	16038448

Scenario 5 Date : 09/29/1993
Contaminant Reduction in Pulp and Paper

	Air Emissions (tonnes)		
	Sulphur Oxides	Nitrogen Oxide	Volatile Org C
Agriculture	0.02	3.65	0.28
Forestry	0.00	0.00	0.00
Fishing	13.26	7.39	0.11
Mining	1.36	167.14	7.58
Food	1086.37	1959.62	534.46
Textile	1281.15	1680.23	1948.77
Knitting	0.00	0.00	0.00
Wood	0.75	15.04	7.91
Furniture	0.00	0.00	0.00
Paper	3965.22	2762.18	228.05
Print.	31.77	82.08	1.31
Prima.	17427.49	13850.55	3738.78
Metal	1547.41	1102.93	494.87
Machinery	177.33	353.68	1181.56
Transportation	2141.11	1661.80	97.92
TOTALS	549715.11	200946.29	16523.49

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Energy Used (terajoules)

	Coal	Crude Oil	Natural Gas
Agriculture	9960.86	0.00	12620.09
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	14555.62	0.00	18074.14
Food	9659.47	0.00	43908.03
Textile	2535.89	0.00	11527.13
Knitting	1629.21	0.00	7405.72
Wood	1887.76	0.00	8581.01
Furniture	1263.04	0.00	5741.26
Paper	30406.36	0.00	83673.52
Print.	2988.59	0.00	13584.93
Prima.	274484.20	0.00	95601.55
Metal	6465.47	0.00	29389.41
Machinery	7728.64	0.00	35131.28
Transportation	22508.73	0.00	102315.57
TOTALS	540661.53	1825093.03	904945.73

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

	Energy Used (terajoules)		
	Electricity	Nuclear Steam	TOTAL
Agriculture	8554.81	3769.81	34905.56
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	8141.00	0.00	40770.76
Food	7054.13	678.38	61300.01
Textile	1851.91	178.09	16093.03
Knitting	1189.78	114.42	10339.13
Wood	1378.60	132.58	11979.95
Furniture	922.37	88.70	8015.37
Paper	22064.36	0.00	136144.23
Print.	2182.51	209.89	18965.93
Prima.	19981.60	0.00	390067.35
Metal	4721.61	454.07	41030.56
Machinery	5644.08	542.78	49046.79
Transportation	16437.70	1580.78	142842.78
TOTALS	219720.04	48780.52	3539200.86

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Waste Generated (tonnes)

	ONP	Fine Paper	Boxboard
Agriculture	15015.91	31439.57	29093.33
Forestry	953.99	1997.42	1848.36
Fishing	146.21	306.14	283.29
Mining	0.00	0.00	0.00
Food	37566.37	78654.60	72784.85
Textile	2197.20	4600.39	4257.08
Knitting	2744.75	5746.82	5317.96
Wood	3419.64	7159.88	6625.56
Furniture	6589.10	13795.93	12766.39
Paper	8336.45	17454.43	16151.86
Print.	4142.18	8672.68	8025.47
Prima.	15312.31	32060.15	29667.60
Metal	18810.53	39384.54	36445.39
Machinery	7597.09	15906.41	14719.36
Transportation	28009.35	58644.57	54268.11
TOTALS	515120.01	1078532.51	998045.01

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Waste Generated (tonnes)

	OCC	Mixed Paper	Magazines
Agriculture	38478.28	7038.71	11261.94
Forestry	2444.60	447.18	715.49
Fishing	374.68	68.54	109.66
Mining	0.00	0.00	0.00
Food	96263.84	17609.24	28174.78
Textile	5630.33	1029.94	1647.90
Knitting	7033.42	1286.60	2058.56
Wood	8762.83	1602.96	2564.73
Furniture	16884.57	3088.64	4941.83
Paper	21362.14	3907.71	6252.33
Print.	10614.33	1941.65	3106.63
Prima.	39237.80	7177.65	11484.23
Metal	48201.97	8817.43	14107.89
Machinery	19467.55	3561.14	5697.82
Transportation	71773.95	13129.38	21007.01
TOTALS	1319995.01	241462.50	386340.00

Scenario 5 Date : 09/29/1993
Contaminant Reduction in Pulp and Paper

	Waste Generated (tonnes)		
	Tel. Books	Glass Cont.	Plastic
Agriculture	469.25	5161.72	8915.70
Forestry	29.81	327.93	566.43
Fishing	4.57	50.26	86.82
Mining	0.00	0.00	0.00
Food	1173.95	12913.44	22305.04
Textile	68.66	755.29	1304.59
Knitting	85.77	943.51	1629.70
Wood	106.86	1175.50	2030.41
Furniture	205.91	2265.00	3912.28
Paper	260.51	2865.65	4949.76
Print.	129.44	1423.87	2459.42
Prima.	478.51	5263.61	9091.68
Metal	587.83	6466.12	11168.75
Machinery	237.41	2611.50	4510.77
Transportation	875.29	9628.21	16630.55
TOTALS	16097.50	177072.50	305852.50

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

	Waste Generated (tonnes)		
	Alumin. Cans	Tinplate	Used Tires
Agriculture	1407.74	2346.24	7507.96
Forestry	89.44	149.06	477.00
Fishing	13.71	22.85	73.11
Mining	0.00	0.00	0.00
Food	3521.85	5869.75	18783.19
Textile	205.99	343.31	1098.60
Knitting	257.32	428.87	1372.38
Wood	320.59	534.32	1709.82
Furniture	617.73	1029.55	3294.55
Paper	781.54	1302.57	4168.22
Print.	388.33	647.22	2071.09
Prima.	1435.53	2392.55	7656.16
Metal	1763.49	2939.14	9405.26
Machinery	712.23	1187.05	3798.55
Transportation	2625.88	4376.46	14004.67
TOTALS	48292.50	80487.50	257560.00

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Waste Generated (tonnes)

	Yard Waste	Food Waste	Wood Waste
Agriculture	9854.19	42701.51	126227.53
Forestry	626.06	2712.91	8019.49
Fishing	95.95	415.80	1229.12
Mining	0.00	0.00	0.00
Food	24652.93	106829.38	315792.34
Textile	1441.91	6248.30	18470.24
Knitting	1801.24	7805.39	23073.06
Wood	2244.14	9724.61	28746.36
Furniture	4324.10	18737.76	55389.64
Paper	5470.79	23706.77	70078.25
Print.	2718.30	11779.32	34820.18
Prima.	10048.70	43544.38	128719.11
Métal	12344.41	53492.43	158125.98
Machinery	4985.59	21604.23	63863.05
Transportation	18381.13	79651.58	235453.57
TOTALS	338047.50	1464872.51	4330227.54

Scenario 5 Date : 09/29/1993
Contaminant Reduction in Pulp and Paper

	Waste Generated (tonnes)		
	Demol. Waste	Diapers	Foundry Sand
Agriculture	11261.94	469.25	30970.32
Forestry	715.49	29.81	1967.61
Fishing	109.66	4.57	301.57
Mining	0.00	0.00	0.00
Food	28174.78	1173.95	77480.65
Textile	1647.90	68.66	4531.73
Knitting	2058.56	85.77	5661.05
Wood	2564.73	106.86	7053.01
Furniture	4941.83	205.91	13590.02
Paper	6252.33	260.51	17193.92
Print.	3106.63	129.44	8543.24
Prima.	11484.23	478.51	31581.64
Metal	14107.89	587.83	38796.71
Machinery	5697.82	237.41	15669.00
Transportation	21007.01	875.29	57769.28
TOTALS	386340.00	16097.50	1062435.01

Scenario 5 Date : 09/29/1993
Contaminant Reduction in Pulp and Paper

	Waste Generated (tonnes)		
	Foundry Sand	Other	TOTAL
Agriculture	30970.32	88687.75	468308.83
Forestry	1967.61	5634.51	29752.60
Fishing	301.57	863.58	4560.08
Mining	0.00	0.00	0.00
Food	77480.65	221876.40	1171601.32
Textile	4531.73	12977.23	68525.27
Knitting	5661.05	16211.19	85601.93
Wood	7053.01	20197.26	106650.08
Furniture	13590.02	38916.88	205497.62
Paper	17193.92	49237.14	259992.92
Print.	8543.24	24464.73	129184.14
Prima.	31581.64	90438.33	477552.68
Metal	38796.71	111099.67	586653.26
Machinery	15669.00	44870.32	236934.28
Transportation	57769.28	165430.20	873541.49
TOTALS	1062435.01	3042427.53	16065305.16

Scenario 5 Date : 09/29/1993
Contaminant Reduction in Pulp and Paper

Discharge Contaminants (tonnes)

	Amonia-N	Oil & Grease	TSS
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	1223.00	516.07	3314.15
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	1131.01	0.00	18337.64
Print.	0.00	0.00	0.00
Prima.	3975.28	3953.56	27866.76
Metal	1106.60	0.00	43287.79
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	9637.47	7437.09	135601.39

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

	Discharge Contaminants (tonnes)		
	Phospurus	Cyanide	Phenolics
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	0.00	62.76	4.23
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	616.34	0.00	0.00
Print.	0.00	0.00	0.00
Prima.	0.00	329.05	59.02
Metal	4.64	35.63	321.17
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	955.55	438.72	391.43

Scenario 5
Contaminant Reduction in Pulp and Paper

Date : 09/29/1993

Discharge Contaminants (tonnes)

	Copper	Lead	Zinc
Agriculture	0.00	0.00	0.00
Forestry	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Mining	66.56	5.51	56.80
Food	0.00	0.00	0.00
Textile	0.00	0.00	0.00
Knitting	0.00	0.00	0.00
Wood	0.00	0.00	0.00
Furniture	0.00	0.00	0.00
Paper	0.00	0.00	191.50
Print.	0.00	0.00	0.00
Prima.	0.00	21.93	115.78
Metal	1.20	0.00	1664.56
Machinery	0.00	0.00	0.00
Transportation	0.00	0.00	0.00
TOTALS	85.55	93.97	2055.20

Appendix F.

Mathematical derivations of LINK model

The economy-environment linkages are articulated within a dynamic, spatial and general equilibrium framework. The economic core of this framework is an input/output system which organizes the activities of production, consumption and accumulation within a consistent accounting framework that is incorporated within the traditional System of National Accounts (SNA).

F.1 The general structure

Three basic matrices define the structure of the traditional system: a "Make" matrix "V", a "Use" matrix "U", and a final demand matrix "F". The new adjusted system starts with these typical matrices and adjustments and changes are made to each one in a manner that preserves consistency across all the component parts.

The typical element of the Make matrix, $\{v_{ij}\}$ is the value of commodity i produced by industry j. Thus each industry may, and typically does, produce more than one commodity. The Make matrix V has as many rows as there are commodities, and as many columns as there are industries. The incorporation of the environmental perspective necessitates the reformulation of the traditional Make matrix in a way that allows the production of recyclables and the management of waste. The changes that follow from this will be detailed below.

The typical element of the Use matrix, $\{u_{ij}\}$, represents the value of commodity i used in production by industry j. Additional rows of the Use matrix are organized into a primary input matrix, "Y", whose typical element $\{y_{ij}\}$, represents the value of each primary input k used in industry j. The usual categories of primary inputs include : non-competitive imports, indirect taxes, labour income including benefits, net income of unincorporated business and other operating surplus.

The environment-economy linkages perspective introduces two basic changes to the structure of the U matrix. First, many new producible inputs will be allotted new rows. These are the recyclable products, and services provided by the waste management and environmental protection industry (EPI). Second, the primary input matrix has been expanded and reorganized to include the use of renewable and non-renewable resources extracted directly from the environment.

The Final Demand matrix, F, whose typical entry $\{f_{is}\}$, defines the deliveries of commodity i to final demand category s (i.e., consumption, investment, government expenditures, exports to other provinces, and exports to the rest of the world). The primary input rows of the Final Demand matrix, are grouped into a matrix YF, with typical elements, $\{yf_{ks}\}$.

Several adjustments are needed to introduce the environmental linkages. First, households, institutions and government produce waste and recyclable products. Second, business investment is allowed to create capacity for future production. The system is made dynamic by linking business investment to output increases.

The organization of these matrices before and after incorporating the environment-economy linkages are presented in Table F-1 and Table F-2, respectively.

Table F-1 Traditional input-output framework

	Commodities	**Industries**	**Final Demand**	**Row Total**
Commodities		U	F	q+m
Industries	V			g
Primary inputs		Y	Y_F	y_T
Column total	q'	g'	F'^T	

The row totals, q, represent the total value of domestic production of each commodity and m represents the total value of imports of each commodity; the Column Totals, g', the value of gross output (value of sales) of each industry ; the totals, e_c, the total value of each Primary Input ; and the total f_w, the total value of each Final Demand category.

Table F-2 Modified make matrix (output) for LINK model

	Industries	**Waste material processing**	**C/S/T/P**	**Final demand**	**Row total**
Commodities	V_{ij}				q_i
Recycled material		$_{RM}kl$			RM_k
Recyclable waste	WM_{kj}			WM_s	WM_k
Collect/sort/transport			CSTP		q_{cstp}
Column total	g_j	g_l	g_{cstp}	WM_s	

A major departure from the traditional Input/Output framework is the inclusion of the Final Demand sectors into the Make matrix. Here households and institutions as well as industries produce waste. In addition recycled material and recyclable waste are distinguished from the rest of commodities. Also important is the prominent role given to waste management services and environmental protection industries.

Table F-3 Modified use matrix (input) for LINK model

	Industries	**Waste material processing**	**Waste management**	**Final demand**	**Row total**
Commodities	U_{ij}	U_{il}	U_{cstp}	F_{is}	q_i+m_i
Recycled materials	RM_{kj}				RM_k+m_k
Recycled waste		WM_{kl}			WM_k+mw_k
C/S/T/P services	$CSTP_j$	$CSTP_l$		$CSTP_s$	$q_{cstp} + m_{cstp}$
Charges for non-renewable inputs	RN_j	MN_l	RN_{cstp}	RN_s	RN_t
Value added	VA_j^R	VA_l^R	$VA_{cstp}R$	VA_s^R	VA_T^R
Column Total	g_j	g_l	g_{cstp}	F_s	

Similar modifications to the Use matrix (input) are required as shown in Table F-3. The changes introduced alter in a substantive way the various accounting relationships governing the system. A full representation of these accounting relationships and the hypotheses of the model are given below.

F.2 The accounting identities

1) $\Sigma_j V_{ij} = q_i$

Commodity i is produced by many industries.

2) $\Sigma_l RM_{kl} = RM_k$

Recycled material k is produced by waste material processing and is used only by industries. It may be a substitute for virgin inputs.

3) $\Sigma_j WM_{kj} + \Sigma_f WM_{kf} = WM_k$

Waste material is produced by industries, households and institutions.

4) $CSTP = q_{cstp}$

Collection, sorting, transportation and environmental protection services are defined as a single specific and unique service.

5) $\Sigma_i V_{ij} + \Sigma_k WM_{kj} = g_j$

Industries produce commodities and waste products. Usually, waste products are valued at a zero price. If a zero price is assigned to them, only commodities are counted as outputs of industries.

6) $\Sigma_k RM_{kl} = g_l$

Recycled materials are produced by specific waste material processing industries.

7) $CSTP = g_{cstp}$

Waste management and environmental protection products and services add to the total output of this industry.

8) $\Sigma_k WM_{ks} = WM_s$

Waste generated by households and institutions is added together under final demand.

9) $\Sigma_j U_{ij} + \Sigma_l U_{il} + U_{i\ cstp} + \Sigma_s F_{is} = q_i + m_i$

This equation represents the commodity balance (Supply = Demand) for commodity i. Supply is made of domestic production (q_i) and imports (m_i). Demand comprises intermediate and final demands for commodity i.

10) $\Sigma_j RM_{kj} = RM_k + m_{rk}$

Recycled materials are delivered to industries. The total industrial demand is satisfied by domestic production and imports (m_{rk}).

11) $\Sigma_l WM_{kl} = WM_k + m_{wk}$

Recyclable waste materials are delivered to waste material processing industries. The total demand by the recycling industries is equal to production of recyclables plus net imports (m_{wk})

12) $\Sigma_j CSTP_j + \Sigma_l CSTP_l + \Sigma_s CSTP_s = q_{cstp} + m_{cstp}$

Waste management services and environmental protection services' demand by regular industries, recycling industries and final demand categories must equal available domestic production of these services plus imports (m_{cstp}).

13) $\Sigma_j RN_j + \Sigma_l RN_l + RN_{cstp} + \Sigma_s RN_s = RN_T$

The use and depletion of non-renewable resources is charged as a cost against output of each of the respective industries. Non-renewable resources are treated here as if they were non-competing imports. They are in a sense imported from the environment.

14) $\Sigma_j VA_j^R + \Sigma_l VA_l^R + VA_{cstp}^R + \Sigma_s VA_s = VA_T^R$

Value added is treated as the sum of factor payments that are left after paying for intermediate inputs and the charges for non-renewable resources.

15) $\Sigma_i U_{ij} + \Sigma_k RP_{kj} + CSTP_j + RN_j + VA_j^R = g_j$

The total value of inputs used to produce output j is equal to the value of that output. This follows from treating value added as a residual item.

16) $\Sigma_i U_{il} + \Sigma_k WM_{kl} + CSTP_l + RN_l + VA_l^R = g_l$

The output of waste material processing and cstp industries fully cost out.

17) $\Sigma_i U_{icstp} + NR_{cstp} + VA_{cstp}^R = g_{cstp}$

18) $\Sigma_i F_{is} + CSTP_s + NR_s + VA_s^R = F_s$

The above 18 identities depict in algebraic form the accounting structures in Table F-1, Table F-2 and Table F-3.

F.3 The hypotheses of the LINK model

To go from the accounting framework to a model of the economy it is necessary to make a number of simplifying assumptions. Traditionally, the most restrictive ones are in the area of fixed market shares and fixed input coefficients. The ease with which a linear system works compensates for the limited flexibility that fixed coefficients lend to the system. Furthermore, in this project, by allowing for some substitution among technologies, the restrictiveness of the assumption of fixed input coefficients is less stringent than in many other applications of input/output analysis. The following description of the model starts with a very simple system that is subsequently made more complex.

There is a logical order to the hypotheses of the model. The discussion begins with the Make matrix conditions. Next will be the hypotheses of the Use matrix to be followed by the Final Demand system.

F.4 The market structure

19) $V_{ij} = d_{ij}\ q_i$

Where d_{ij} represents the fixed market share of industry j in the production of commodity i. This assumption, together with the Industry Output identity (5), implies that industry gross outputs can be calculated from commodity output assuming, for convenience, that waste products are assigned a zero price. We have :

20) $g_j = \Sigma_i\ V_{ij} = \Sigma_i\ d_{ij}\ q_i$

Thus the vector of industry gross outputs $\{g\}$, is related to the vector of commodity outputs $\{q\}$, by the following matrix equation:

21) $\{g\} = [D]\ \{q\}$

Where { } indicates a column vector and [ ] indicates a matrix of coefficients.

Equation (21) indicates that the fixed market share assumption implies that the production of the j^{th} (multi-product) industry is a weighted sum of the commodity outputs which it produces, where the weights are the coefficients d_{ij}. These weights sum to one across industries. Since, $q_i = \Sigma_j\ V_{ij} = \Sigma_j\ d_{ij}\ q_i$, it follows that:

22) $\Sigma_j\ d_{ij} = 1$ for $i=1,2,3,....,n$.

Waste generation by type of waste or pollutant k is linked to employment in industry j. But since employment is linked by fixed employment-output coefficients, we establish a direct and fixed link to industry gross outputs g_j by equation 23, below:

23) $WM_{kj} = w_{kj}\ g_j$

Where w_{kj} are waste (pollutants) of type k measured by physical units per $1000 of industry j output. w_{kj} could be ONP tonnes or litres or CFCF per $1000 worth of output of industry j.

Waste and pollutants are also generated by households and the institutional sectors. This type of waste generation is related to Final Demand categories directly.

24) $WM_{ks} = w_{ks}F_s$

Finally,

25) $RM_{kl} = r_{kl}\ RM_k$

Equation (25) establishes a market share for recycling industry l in the production of the k^{th} recycled material.

F.5 The industry-production function hypotheses

The production function underlying most of the production processes of the system is assumed to be of the fixed proportion type (generally known as a Leontieff production function).

26) $g_i = \text{Min}\ [U_{ij}/b_{ij}]$ for i=1,2,...,n and j=1,2,...,m.

Where $b_{ij} = U_{ij}/g_j$ is the amount of commodity i needed to produce one unit of output j. Thus, the use of each commodity is assumed to be a fixed proportion of industry gross output:

27) $U_{ij} = b_{ij}\ g_j$

Therefore, the following sets of equations hold:

28) $RM_{kj} = r_{kj}\ g_j$

29) $CSTP_j = cstp_j\ g_j$

30) $RN_j = rn_j\ g_j$

31) $VA_j^R = v_j\ g_j$

32) $U_{il} = b_{il}\ g_l$

33) $WM_{kl} = b_{kl}\ g_l$

34) $CSTP_l = cstp_l\ g_l$

35) $RN_l = rn_l\ g_l$

36) $VA_l = v_l\ g_l$

F.6 The final demand system

Final Demand categories include consumption, investment, government expenditures, exports and imports. Some are endogenously determined by being related to other components of the system, while some are purely exogenous to the system. In this model we treat consumption, investment and imports as endogenous variables.

When consumption is related to income, the household sector becomes a sort of producing sector whose output can be solved within the production system. Let

37) $F_c = ßY$

Where F_c is total consumption, ß is the long-run Marginal Propensity to Consume, and Y is income.

Income is defined as the sum of Labour Income, W, and Net Income of Unincorporated Business, UIC. Thus, income is related to gross industry output by the vectors of primary input coefficients (components of value added) w and e.

38) $Y = \Sigma_j (w_j + e_j) g_j + \Sigma_l (w_l + e_l) g_l + (w_{cstp} + e_{cstp}) g_{cstp} + (w_c + e_c)F_c + W^f$

Where W_f is the sum of Labour income associated with all final demand categories except consumption and competitive imports.

The integration of consumption into the model is completed by assuming that the values of commodities and primary inputs that enter into consumption expenditures are fixed proportions of the total value of consumption.

39) $Fc_i = c_i F_c$

or, in matrix-vector notation:

$\{F_c\} = \{c\} F_c$

Where c_i is the proportion of consumption used to purchase commodity i and {c} is the column vector of c_i's. Also,

40) $W_c = (w_c + e_c) F_c$

Where w_c is the proportion of the total value of consumption spent on Labour, and e_c is the proportion of the total value of consumption which generates net income of unincorporated business.

The income concept defined in (37) does not include dividends and government and private transfers and may, therefore, not accurately represent personal income. On the other hand, the inclusion of dividends, government transfers and private transfers would require information on the distribution of dividends and transfers between Ontario, the other provinces, and abroad. This information is not available.

Investment plays a dual role in the model. On the one hand, it is part of the current demand for output. On the other hand, it builds the capital stock of the economy and, therefore, increases the capacity of the economy to produce future output.

41) $FI_t = k \Delta g + \tau K_t$

Where FI_t is total investment in year t, k is the capital-output ratio, τ is the fraction of capital that depreciates within a year, Δg is the change in the total gross output of the economy and K_t is the capital stock in year t.

Equation (41) can be rewritten as:

42) $FI_t = kg_t - kg_{t-1} + \tau K_t$

But in the input/output framework there is a column vector of investment deliveries by commodity. To relate this vector of deliveries to investment by commodity to the activity of building capacity by industry, a distribution matrix [S] is required where the typical element, s_{ij}, is the deliveries of commodity i, to build capacity in industry j, per unit of output of industry j.

43) $FI_{it} = \Sigma_j [k_j \, s_{ij} \, g_{jt} - k_j \, s_{ij} \, g_{jt-1} + \tau_{ij} \, K_{jt}]$

In matrix-vector notation:

44) $\{FI_t\} = [\hat{k}] \, [S] \, \{\Delta g_j\} + [\tau] \, \{K_t\}$

There are two types of imports in the model, competitive and non-competitive. Competitive imports, which make up the major portion, are imports for which there exists domestically produced counterparts. Non-competitive imports have no corresponding domestic production.

Competitive imports are assumed to be a constant fraction of total industry and Final Demand use (exclusive of imports) for each commodity.

45) $MC_i = m_i \, [\Sigma_j \, b_{ij} \, g_j + \Sigma_l \, b_{il} g_l + b_{icstp} \, g_{cstp} + \Sigma_j [k_j \, s_{ij} \, g_{jt} - k_j \, s_{ij} \, g_{jt-1} + \tau_{ij} \, K_{jt}] + c_i \beta y + F_{io}]$

Where m_i is the fraction of total domestic use of commodity i supplied by imports and F_{oi} is the Final Demand use of commodity i exclusive of imports. In matrix-vector notation, (45) becomes:

46) $\{mc\} = [\hat{m}] \, [\, [B_J] \, \{g_J\} + [B_L]\{g_l\} + b_{cstp} g_{cstp} + [\hat{k}][S]\{\Delta g_j\} + [\Gamma]\{K\} + \{F^o\}$

Where $\hat{m}$ is a diagonal matrix of m_i values.

Non-competitive imports by industry are related to industry outputs and are added to non-competitive imports to calculate total non-competitive imports,(MNC).

47) $MNC = <mnc> \{g\} + MNC_F$

Where $MNC_F = \Sigma_s MNC_s$.

Total imports are the sum of competitive and non-competitive imports.

F.7 The full model

Combining the equations above reduces the system to a small subset of equations.

From the Use and Final Demand systems and substituting the various assumptions made above in the relevant places:

48) $(1-m_i)(\Sigma_j b_{ij} g_j + \Sigma_l b_{il} g_l + b_{i\,cstp} g_{cstp} + \Sigma_i c_i \beta Y + \Sigma_j (k_j s_{ij} g_{jt} - k_j s_{ij} g_{jt-1} + \tau_{ij} K_{jt}) + f_i^o) = q_i$

49) $\Sigma_j r_{kj} g_j = RM_k + m_{rk}$

50) $\Sigma_l b_{kl} g^l = WM_k + m_{wk}$

51) $\Sigma_j cstp_j g_j + \Sigma_l cstp_l g_l + \Sigma_s cstp_s F_s = q_{cstp} + m_{cstp}$

From the Make matrix the following are obtained:

52) $\Sigma_i d_{ij} q_i + \Sigma_k w_{kj} g_j = g_j$

53) $\Sigma_k r_{kl} RM_k = g_l$

54) $\Sigma_j w_{kj} g_j + \Sigma_s w_{ks} F_s = WM_k$

55) $q_{cstp} = g_{cstp}$

F.8 Solving the model's equations

Let $G_J = \{g_j\}$, $G_L = \{g^l\}$, $F_S = \{f_s\}$

$Q = \{q_i\}$, $RP = \{RP_k\}$, $WM = \{WM_k\}$

$B_J = [b_{ij}]$, $B_L = [b_{il}]$, $B_{cstp} = [b_{icstp}]$

$F = [f_{is}]$, $R_k = \{r_k\}$, $B_{KL} = [b_{kl}]$

$CSTP_J = \{cstp_j\}$, $CSTP_L = \{cstp_l\}$

$$CSTP_F = \{cstp_f\}\ ,\ W = [wk_j]\ ,\ W_F = [w_{kf}]$$

56) $[I-\hat{m}]([B_J]\ \{g_j\} + [B_L]\ \{g_l\} + [B_{CSTP}]\ \{g_{cstp}\} + \{c\}ßY + \hat{k}][S]\{\Delta g_j\} + [\tau]\{K\} + \{F^{o}\} = \{q\}$

57) $[R]\{g_j\} = \{RM_k\} + \{m_{rk}\}$

58) $[B_L]\{g_l\} = \{WM_l\} + \{mw_k\}$

59) $<cstp_j>\ \{q_j\} + <cstp_l>\ \{g_l\} + <cstp_f>\ \{f_s\} = q_{cstp} + m_{cstp} = g_{cstp} + m_{cstp}$

60) $[D]\ \{q\} + [w]'\ \{g_j\} = \{g_j\}$

61) $[R]'\ \{RM_k\} = \{g_l\}$

62) $[W]\ \{g_j\} + [W_f]\ \{f_s\} = \{WM_k\}$

From (60):

63) $[D]\{q\} = [I-[W]']\{g_j\}$

Multiplying (56) by [D]:

64) $[I-\hat{m}]([D][B_J]\{g_j\} + [D][B_L]\{g_l\} + [D][B_{cstp}]\{g_{cstp}\} + [D]\{C\}BY + [\hat{k}][D][S]\{g_{jt}-g_{jt-1}\} + [D][\Gamma]\{K\} + [D]\{F\} = [D]\{q\}) = [I-[w]']\{g_j\}$

Reorganizing (64) and collecting terms:

65) $[I-\hat{m}]([[D][B_J] + [\hat{k}][D][S] - [I-[W]']\ ]\{g_j\} + [D][B_L]\{g_l\} + [D][B_{CSTP}]\{g_{cstp}\} + [D]\{C\}BY) = -[D][F] - [D][\Gamma]\{K\} + [\hat{k}][D][S]\{g_{Jt-1}\}$

65') $[[[I-\hat{m}]\ [\ [D][B_J]\ ] + [\hat{k}][D][S] - [I-[w']]\ ]\{g_j\} + [D][B_L]\{g_l\} + [D][B_{CSTP}]\{g_{cstp}\} + [D]\{C\}BY = [\hat{k}][D]\{f_o\} - [D]\{F\} - [D][\Gamma][k]$

Representing the simultaneous system of equations above in matrix-vector notation, we have:

$$\begin{bmatrix} [A_1] & (I-\hat{m})[DB_L] & (I-\hat{m})[DB_{CSTP}] & 0 & 0 & (I-\hat{m})D\{C\}ß \\ [R] & 0 & 0 & 0 & -I & 0 \\ [O] & [B_L] & 0 & 0 & -I & 0 \\ <cstp_j> & <cstp_l> & -I & 0 & 0 & 0 \\ [W] & 0 & 0 & 0 & -I & 0 \\ <w_j+e_j> & <w_l+e_l> & <w_{cstp}+e_{cstp}> & 0 & 0 & -I \end{bmatrix} x \begin{bmatrix} g_j \\ g_l \\ g_{cstp} \\ RP_k \\ WM_k \\ Y \end{bmatrix} = \begin{bmatrix} \Phi_1 \\ \Phi_2 \\ \Phi_3 \\ \Phi_4 \\ \Phi_5 \\ 0 \end{bmatrix}$$

Where:

$[A_l] = [\ [I-\hat{m}]\ [\ [D][B_J]\ ] + [\hat{k}][D][S] - [I-[W]']\ ]$

$\Phi_1 = -(I-\hat{m})\ [\ [D]\{F\} -[D][\Gamma]\{K\} +[\hat{k}][D][S]\{g_{Jt-1}\}\ ]$

$\Phi_3 = \{\tilde{m}\tilde{w}_k\}$

$\Phi_4 = -<cstp_f>\{\not{f}\} + \tilde{m}_{cstp}$

$\Phi_5 = -[W_f]\{f\}.$

F.9 Energy and resources: stocks and flows

The energy impacts of Final Demand expenditures are expressed as the total amounts of use of primary energy forms, in terms of both physical quantities and energy units. The primary energy source includes coal, crude oil, natural gas, hydro and other generated electricity, and other primary energy (liquified petroleum gases and steam from nuclear electricity generation.)

Conceptually, energy uses could be computed either from commodity outputs or industry gross outputs. The availability of energy use data for Ontario, based on industry uses, makes the industry-based calculation the most convenient. Because the input/output economic database contains the value of industry gross outputs for Ontario in 1984, these can be related to data on Ontario energy uses in 1984 to link energy uses to industry gross outputs. The 1984 values of industry gross outputs, g_j, g_l, g_{cstp} and consumption, which are calculated from the equations derived in the preceding section of Appendix F, are used as inputs to the energy-use model.

It is assumed that for each industry (and the household sector), both primary energy (EP) and secondary energy (ES) uses are proportional to industry gross output and the total level of household consumption:

66) $EP_{uj} = ep_{uJ}g_J$, $EP_{ul} = ep_{ul}g_l$, $EP_{ucstp} = ep_{ucstp}g_{cstp}$

and,

67) $EP_{uc} = ep_{uc}C$

68) $ES_{vj} = es_{sJ}g_J$ etc...

69) $ES_{vc} = es_{vc}C$

The total uses of ES are the obtained by summing over all users and "grossing up" to account for producer use:

70) $ES_v = a_v(\Sigma_j ES_{vj} + EV_{vc})$

Where a_v is the ratio of gross output to net output of secondary energy form v.

The uses of each EP form to produce each ES form are also assumed to be proportional:

71) $EP_{uv} = et_{uv}ES_v$

Finally, the total use of each EP form can be calculated by summing across primary and secondary uses and "grossing up" to account for producer use:

72) $EP_u = a_u[\Sigma_j EP_{uj} + \Sigma_l EP_{ul} + EP_{ucstp} + \Sigma_v EP_{uv}]$

73) $EP_u = a_u ((\Sigma_j ep_{uj} g_j + \Sigma_l ep_{ul} g_l + ep_{ucstp} g_{cstp} + ep_{uc}C) + \Sigma_v et_{uv}a_v (\Sigma_j es_{vj}g_j + ... +$

$es_{vc}C))$

Where a_u is the ratio of gross output to net output of primary energy of form u.

The flow demands for energy affect the stocks available. Starting from total proven reserves in the amount of E_{ut}. Then each year:

74) $E_{ut} = E_{ut-1} + NE_{ut} - EP_{ut} + ME_{ut} - XE_{ut}$

Where NE_{ut} are new additions to the stocks through exploration and discovering, ME_{ut} are inputs of coals and XE_{ut} are exports. All these variables will be measured in physical terms.

The treatment of other non-renewable resources is not much different than that of energy, except it is generally simpler.

The material balances equation for non-renewable resource m is given in (75).

75) $NR_{mt} + MNR_{mt} = \Sigma_j nr_{mj} g_j + \Sigma_l nr_{ml} g_l + nr_{mcstp} g_{cstp} + nr_{mc} \beta Y + \Sigma_s nr_{ms} f_s$

Available stocks in year t of non-renewable resource m are:

76) $SNR_{mt} = SNR_{mt-1} + NNR_{mt} - NR_{mt}$

F.10 Technological change, alternative technologies and choice

The world of fixed coefficients is indeed a simple world. The system under study is already large and complex and has several components interacting with one another. To begin with, a simple representation of this complex system based on a fixed coefficient linear system has been presented. However, this depiction of the economy and the environment is far from satisfactory and could easily lead to unrepresentative results. To cope with these difficulties and limitations of a fixed coefficient linear system, while preserving its comparative simplicity and ease of implementation, a discrete number of choices are introduced and examined.

Choice in the system takes many forms, but it essentially involves the following:

- a choice between alternative technologies;
- a choice between alternative fuels and energy sources;
- a choice between present and future consumption; and
- a choice between domestic output and imports.

Choice is exercised partly through constraints. There are a number of technological, resource, environmental and behavioral constraints that govern the system. The meaning of the sustainability of an economic system as has been developed in this study is one that requires consistency with a set of overall economic and environmental constraints.

The general structure of the constrained choice system assumes the following form.

$$\text{Maximize } C_T + <\bar{p}>\{K_{T+1}\}$$[1]

The maximand involves maximizing consumption (C) and the value of the stock of capital (K) available in the post-planning period.

Six primary biophysical constraints are imposed on the system. These include:

- water;
- air;
- surface area;
- genetic material;
- minerals and energy; and
- solar radiation.

This set of constraints is generally novel in the sense that other models of economic planning have not constrained the system in terms of these primary constraints. The constraints can be quantitative, qualitative or a combination.

To the extent that Ontario is an open system and operates within a much larger ecological system, trade and financial constraints also become necessary. If, for example, the imposition of a tax on virgin products shifts production to the United States, imports will increase, exports will decrease. Hence, a trade balance constraint prevents a unilateral increase in imports which would be non-sustainable in the long term.

---

[1] The current form of the LINK model does not include an optimization routine. This section describes the theoretical basis for integrating an optimization routine and biophysical constraints into the input/output framework.

When there is more than one type of good, (i.e. consumption now and consumption in the future) in a linear programming model, a way to choose between the two is to put them both in an objective function and maximize subject to the relevant constraints. Since sustainable development implies that today's consumption should not compromise the consumption of future generations, the welfare of future generations must be part of the objective function maximized today.

Applied planning models have long introduced the capital stock in the post plan period into the objective function or simply as equality constraints to be satisfied. In a well known application in Indian planning, Eckaus and Parikh (1968) postulate rates of growth in the post plan period which generate initial values for the capital stock used as a terminal constraint for the current planning period. In much the same way, the capacity of future generations to maintain similar or comparable rates of growth can be preserved subject to an expanded set of constraints (far broader and much more encompassing than simply physical capital) that define sustainability. These exogenously stipulated rates will allow the initial values of the stocks of the constrained resources to be determined at values that are needed to sustain the chosen future rates of growth. These initial values will be used either as the values of these variables in the objective function or the actual values of the constraint constants.

Algebraically, the system involves:

$$\text{Maximize} \quad C_T(t) + \langle \tilde{p}_t \rangle \{K_{t+1}\}$$

t = present generation

$t+1$ = future generation

Subject to:

(1) Material balance equations of the general I/O form.
(2) Investment and resource building equations.
(3) Basic resources constraints.
(4) Other constraints.

In matrix notation this system is as follows:

Column	(1)	(2)	(3)	(4)	(5)
	$X(t)$	$C_T(t)$	$I(t)$	$K(t)$	$K(t+1)$
p'(t)	$-(I-A)$		0	I	$\leq -\bar{c}(t)$
R'(t)	$-I-$	I	I	≤ 0	
w'(t)	$(\hat{\alpha})$				$\leq \bar{L}(t)$
s'(t)	H_g			I	≤ 0
p'(t-1)				I	$\leq \bar{k}(t)$
MAX		1			$\bar{p}'(t)$

The first row of this matrix represents sectoral demand-supply balances: in exactly the same way as matrix $[A_1]$ in section F.4. The second row requires that k_{t+1}, the stock of capital and resources for the next generation, not exceed the sum of investment (net additions) and the present generation's stocks. Row three is the labour and basic resource requirements constraints of the system. Row four restricts the use of capital and resources to their available supplies. The fifth row puts *a priori* upper limits on the amounts of each capital stock which can be accumulated in the economy up to the initial stocks available to the present generation.(**Note**: labour is not the only primary resource, and future generation's resources are included in the welfare function of the present generation.)

When consumption activity is positive, all goods will be produced and some use will be made of all types of resources and capitals; hence "complementary slackness" conditions assure that columns (1), (2) and (4) describe matrix-vector equalities. The equality state of columns (1), (2) and (4) ensure that column (5) is also an equality.

The relationships among shadow prices from all these equalities are easy to write down. Column (5) stipulates that:

$$\bar{p}_t = R_i(t)$$

This together with the fourth column equation means that

$$S_i(t) = P_i(t-1) - \bar{p}_i(t)$$

Substitution with first column equality generates the usual price equals marginal cost condition:

$$P_i(t) = \Sigma_j\ p_j(t)a_{ji} + \Sigma_j\ w_j(t)\alpha_{ji} + \Sigma_j\ [p_j(t-1) - p_j(t)]h_{ji}$$

If each capital stock's (resource stocks) own-rate of return is defined as,

$$r_j(t) = \frac{p_j(t\text{-}1) - \tilde{p}_j(t)}{\tilde{p}_j(t)}$$

the resource stock (capital) cost term at the right end of the $p_i(t)$ equation can be re-written as follows:

$$\text{Capital cost} = \Sigma_j\ r_j(t)\tilde{p}_j(t)h_{ji}$$

Since $S_i(t)$ cannot be negative, $r_j(t)$ cannot be negative as a non-zero valuation is put on future stocks of resources and capital. Actually capital costs and returns on capital rise in proportion to an inverse relationship to the valuation of future capital.

Choice in the model is expressed by the inequality relationship of column 3:

$$P_i\ (t) \geq P_i\ (t)$$

Equality here means the cost of the i_{th} good, $P_i(t)$, does not exceed its exogenously specified use-value, $P_i\ (t)$ in investment. In this case, investment will be positive. A sufficiently high valuation on the i_{th} capital (resource) stock in the post-terminal year will assure that some investment in this type of capital takes place in the present period by the present generation. Equally relevant is the fact that the shadow prices of resources reflect the valuation that the present generation puts on the resource and capital stocks it chooses to hand on to future generations. The higher this valuation, the more valuable is investment and foregoing present consumption.

F.11 Model compromises

The system outlined, while theoretically robust, proved difficult to implement within the scope of this project. Difficulties arose in two regards. First, the system places a heavy demand on data much of which will require substantially greater data collection and synthesis efforts. Second, a practical operational system that the Ministry can use easily and repeatedly in a microcomputer environment cannot at present be produced. The large optimization program that the present configuration requires demands considerable computing power.

The conceptual framework described is, however, a comprehensive and meaningful specification for an analysis of sustainable development that is fully implementable over time. The LINK Model framework has been founded within the general context of proven development planning models. A strength of the approach is that it reduces the definition of the sustainability to an allembracing bequest from one generation to the next without having to face infinite horizon problems that would lead to collapse of the computing system.

The dual solution outlined above, potentially simplifies the problem of sustainability to a set of shadow prices. In this way, the severity of the biophysical constraints and of increased deviation from sustainability can be expressed in terms of increased costs. These shadow prices can be used as indicators of deviation and as early warning signals of the need for corrective action.